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THE BIRTH OF A SICILIAN VOLCANO.

By Prof. A. S. PACKARD

OUR hope in planning a brief journey to Sicily was to ascend Mount Etna, which, as everybody knows, is the highest volcano in Europe, and whose history and appearance have been recorded from the days of Homer. Although we did not ascend to the very summit, we had the unexpected pleasure of tramping up the ash-cone of one of the many minor volcanoes or monticles which stud the flanks of the majestic mother volcano, who looks down from her serene heights upon a numerous progeny scattered about her skirts.

Monte Gemellaro is the youngest of the brood. It is situated four thousand six hundred and fifty feet above the Mediterranean, and the crater itself is four hundred and fifty feet in height above the side of the parent mountain.

This symmetrical, double-headed cone, too recently upheaved to have been much despoiled by rains and frosts, suddenly appeared after a few days' disturbance, and nearly each stage in its rapid development was studied by experienced observers, or at least in a more careful manner than any of its predecessors, since so much more attention than formerly is now paid to the study of volcanism.

In May, 1886, just three years previous to our visit, and within the short period of twelve days—days of fear and suspense to the inhabitants of the hamlets and villages below—the cone was formed by the upheaval of great masses of lava, ashes, and slag, accompanied with clouds of steam and deadly gases, the lava stream threatening Nicolosi, the highest town on the flanks of Etna, and which during the eruption of 1669 was leveled to the

ground. Then a period of rest and quiet ensued, and the scene three years later was one of utter desolation, the eye within a radius of two or three miles resting only on vast wastes of volcanic sand, slag, and ashes, with the rugged wild lava streams below.

Late in the afternoon of a day in the middle of April we left Naples, then cold and raining, with thunder and lightning; and after a particularly rough and disagreeable night in a steamer without ballast, which bobbed about on the chopping sea like a cork, we landed early in the morning at Palermo. The day was spent in visiting the fine zoölogical museum, and in wandering through the attractive botanical garden of that beautiful city.

The traveler who would see Etna to the best advantage should approach it from the west and south as well as the north. Leaving Palermo the next morning by an early train we soon reached the junction of Termini. At this point the railroad turns south and runs into the interior; but before we left the coast we could see, some eighty miles distant, heavy clouds of steam and ashes drifting from the eastward, and we were sure that they arose from the island of Volcano, then in eruption, although inquiries from our fellow-travelers as to whether this were so failed to meet a response; either they were stupid or our limited Italian vocabulary was at fault.

It was not until we reached the neighborhood of Castrogiovanni that we had a good view of the noble cone of Etna, distant some forty miles. From this point of view, almost directly west, the grand mountain mass is seen to rise by a very gradual ascent from the regions below, its upper third snow-clad, its steepest slope toward the south. It has undergone little change since the days of Pindar, who nearly twenty-five hundred years ago sang of "the snowy Etna, the pillar of heaven—the nurse of everlasting frost, in whose deep caverns lie concealed the fountains of unapproachable fire—a stream of eddying smoke by day, a bright and ruddy flame by night; and burning rocks rolled down with loud uproar into the sea" (First Pythian Odes). It was the 16th of April, and the season was a late one, but the poplars were leaved out and the vines were much more advanced than in Naples. The green fields were crowded with poppies, wild peas, and other spring flowers in profusion, while farther on in our route, in the outskirts of Catania, the almonds and figs were fully formed on the trees, though still green.

Not stopping at Catania, we took the night steamer for Malta, where we spent a most interesting day, returning by night to Syracuse—a memorable trip one should not miss—and the morning of the 19th found us at Catania.

After lunch we drove through the long, straight Strada Etnea

which by a gradual ascent of ten miles ends in Nicolosi, whence tourists start for the ascent of Etna. Passing beyond the city limits, past the lava stream of 1669 on the left, through villages and hamlets surrounded by vineyards and orange trees, we finally not long after sunset drew up at the door of the Hôtel d'Etna in Nicolosi.

It was Good Friday, and as we stepped out of our carriage a festal, torchlit procession issued from a church near by, and passed up a street parallel to ours amid blazing red lights and the explosion of noisy fireworks, toward another church at the upper end of the village. A *gamin* eagerly accosted us, gesticulating and shouting in our ears, "*Jesu Cristo morte!*" and appealing to us to follow on with him. Hastily leaving our traveling bags in the hotel, we walked up the street in the gathering gloom and by a short cut entered the church just before the procession reached the door. To the beat of muffled drums and amid glaring, smoking torches entered a priest, followed by a company of men bearing a rude image of the body of Christ stretched on a bier; then poured in a motley crowd of men, women, and children, each wearing a crown of thorns, to be succeeded by a standing image, life-size, of the Virgin dressed in black, and borne by women, also in mourning garb. Not waiting to witness the final ceremonies, we left the church resounding with the music of the brass band, reeking with the lurid smoke of pitch-pine or tar torches, and betook ourselves to the hotel.

It was a jovial company assembled in this wayside inn. Half a dozen German teachers and physicians were making merry over the wine of the country, and cordially invited us to ascend the mountain with them the next day. But we had heard of the new volcano, and had made our plans to visit that. At a late hour, all the rooms having been taken by them, we slept on cots in the dining room.

The morning of the 20th was light and clear, and the unclouded summit of the volcano was like polished alabaster. After an early breakfast the guide and myself, mounted on mules, took the road for Monte Gemellaro. Leaving on our left the old lava stream of 1669, which looked like an unused railway embankment rising about twenty-five feet in height, we soon came to the forked end of the stream, or *sciarra*, of 1886. To our left towered the double-headed cone of Monte Rosso with its retinue of monticles around its base. The vines were still in full leaf, and the apple trees in blossom; but we soon rode into a cooler zone, where the vines had just begun to leaf out, and they formed the only vegetation except clumps of yellow-flowered broom, with copses of leafless, slender chestnuts. Over the reddish volcanic soil ran nimble lizards—not the beautiful green ones of the

regions below, but, chameleonlike in their adaptation to their environment, they were dull reddish brown.

Lunching at the last house, an empty wooden structure, we soon passed beyond the groves of low, slender chestnut trees, above all vegetation, into the desert zone, and, leaving the mules, ascended the crater cone of Monte Gemellaro. The mountain or hill is an ash heap or cinder cone, the loose material likened by M. Émile Chaix to coke or black powdery scoriæ, with lava underneath, and it rises upward of four hundred and fifty feet above the sides of Mount Etna, with a diameter of about six hundred feet. The crater is estimated to be one hundred and twenty-five feet deep, with two fissures at the bottom three or four yards wide. It was named after the distinguished geologist and student of volcanism, the late Prof. Gemellaro, of Catania.

On the way up we passed small fissures, still steaming, and their edges incrusted with deposits of sulphur and arsenic. Such fissures are called *solfataras*. Small heated masses of rock and clay, still warm, lay scattered about. The structure of the inner walls of the crater is simple, reminding us of the upper edge of the crater of Popocatepetl. Under the bed of ashes the rim of the cone is made up of irregular layers of lava which slope away from the center down the sides. In fact, a crater of this sort is formed by the upthrust of masses of lava; and the repeated showers of stones, bombs, ashes, and lapilli, or coarse gravelly ashes, falling down vertically over the vent, give the regular conical shape to the crater, while the sloping sides of the funnel of the crater are formed by loose ashes rolling down the incline of the irregular vent or fissure at the bottom, which is kept clear by the passage of steam and showers of ashes during the progress of an eruption. The origin of the lava stream which threatened Nicolosi and the other towns below was mostly covered up by the thick layer of ashes. It should be understood that by the term "ashes" is meant the fragments of lava and clay, often with obsidian or volcanic glass, shattered during the more violent throes of the crater; the earthquakes and tremblings being due to the expansion of the steam pent up in the subterranean cavities and reservoirs of lava deep down in the bowels of the earth.

From the accounts published in the scientific journals we gather the facts for the following history of this eruption.

After a series of outbreaks, both from the crater of Etna and at other points below, on the 19th of May the lava began to stream down toward Nicolosi, accompanied by severe earthquakes. The stream divided, and the eruption assumed terrific proportions. The lava advanced over three kilometres in eight hours, steadily pushing on toward the village. On the 20th ten other craters opened. A dispatch stated: "Three of the craters are raging

Lava at Altarelli, Etna.

fearfully, emitting huge stones to a considerable height, and the roar and tumult are terrible"; meanwhile the central crater on the summit of Etna continued to vomit great columns of steam and ashes. "On Sunday the eruption had greatly diminished, but on Monday morning it broke forth with great violence, and a fresh crater sent out a stream of lava one hundred and fifty metres wide and twenty-three deep, which flowed down at the rate of one hundred and sixty to one hundred and ninety feet an hour toward Nicolosi. On Monday evening the news was very disquieting. The violence of the eruption was then greatly increasing, and Nicolosi seemed doomed to destruction. The noise at a considerable distance is described as resembling a continuous cannonade." On the 19th Prof. Amico recorded ninety-two earthquakes; on the following day, only twenty; but afterward the number rose from twenty-five to thirty, twenty-seven, twenty-five, and finally to fifty-two on the 25th. The eruption reached its height on the 31st of May, and the people were so alarmed that the town was evacuated.

The great lava stream which threatened Nicolosi divided into two, one advancing toward Altarelli and the other descending on the east side of Monte Rosso, and on the 3d of June stopped within three hundred and seventy metres of the town, parting just behind a structure like that seen in the accompanying picture. The inhabitants affirm that this was in direct answer to the prayers of the clergy, who with their parishioners in solemn procession marched toward the advancing lava when the danger seemed most imminent.

According to Prof. Silvestri, the lava stream of 1886, like that of 1883, flowed from the rent or fissure which was opened in 1875 in the flank of the volcano, and extended in a northeast and southwest direction.

In the September following it was safe to visit the scene, and the Count L. dal Verme estimated that during the eruption Gemellaro ejected about sixty-six million cubic metres of eruptive matter, covering a space of five square kilometres and a half on the flank of the mountain, and approaching within less than half a mile of Nicolosi, situated near the upper limit of the vine. The vineyards were destroyed to the extent of some twenty thousand lire.

In 1890 M. Émile Chaix, of Geneva, ascended Mount Etna, camping out several days on or near its summit. From his bright and interesting account, entitled *Une Course à l'Etna*, originally contributed to the *Journal de Genève* for September, 1890, we quote the following description of the crater of Gemellaro as it appeared the summer succeeding that in which we visited it:

"It still gives out a little sulphurous vapor, and is carpeted

with the red, yellow, and white products of the solfatara. But the richest volcanic colors are seen in a solfatara opening in an eminence on the outer and southern side of the volcano. An explosion has laid bare a vertical wall above a mysterious opening, and from this opening different gases have passed out and coated the walls with yellow, white, orange, red, and violet incrustations; these hues are remarkably bright and are enhanced by the setting of ebony which surrounds them.

"The inundations of lava poured out from a series of pits or *bocche di fuogo* situated in a line below the cone, on the rent from which escaped all that overflowed from Etna in 1886. They are empty monticles, which have the appearance of having been formed of burned coke. They are two, three, and ten metres high, and it is difficult to believe, on looking at them, that they could have given birth to this immense sea of lava which has climbed cones thirty to forty metres high, and which rises with a formidable hill in its middle.

"All this coke which we see is not lava, it is only slag. But this slag, these scoriæ, cover everything up, though it would not have been visible had there not been a deep excavation along the course of the lava stream, next to the pits. This great ravine, nearly a kilometre in length, thirty to fifty metres in width, and from four to twelve metres deep, with vertical walls, enabled us to see the internal structure of a lava stream. It is formed by the superposition of alternating layers of compact lava, a yard thick, with black ashes. In certain places we could count five or six layers, one over the other.

"It appears, then, that the lava stream, itself the result of the eruption, is formed of sheets of lava, which flow out one after the other and pass one above the other, each covering the scoriæ, or rather a part of the scoriæ of the surface of the preceding layer, without filling the interstices. But while layers of ashes or scoriæ only ten to twenty inches thick separate the lava layers, the sides and ends of the lava streams form great heaps of large pieces of loose coke, amid which one can detect the compact lava."

We had left our mules some distance down the mountain, and, while the guide went for them, as we were to return by a different route, I strolled about, enjoying the wondrously beautiful scene far below. A gentle sirocco was blowing, and far down beyond the fields of ashes and cinders a soft, delicate haze hung over the land of the vine and orange, and spread over the deep blue Mediterranean beyond.

We returned to Nicolosi in the hot afternoon sun, passing around by the south of Monte Rosso, skirting the right side of the eastern lava stream, whose entire length was about four miles, and whose rough, broken surface is so well represented by the

ERUPTION, SEEN AT A DISTANCE OF FIFTY METRES, ON THE 20TH OF MAY, 1886, AT 1.30 P. M.

photograph here reproduced. The stream ceased flowing when within three hundred and seventy yards of the building nearest the volcano.

It was interesting to observe that the stream did not actually plow up the loose volcanic earth of the vineyards, but simply rolled or flowed over the surface without throwing up the soil. The angle of the sides of the stream is steep and the sides are rough, like frozen foam or congealed slag from a furnace.

The same afternoon we returned to Catania, visited the university, and the next day found us on our way to Taormina, catching from the window of our car fine views of Mount Etna. The accompanying picture will give a faint idea of the wondrously fine view of the volcano as seen from the walls of the interesting ruins of the Greek-Roman theater at Taormina, as well as the town itself, and the flanks of Etna studded with villages and hamlets. It is a view said to be the finest in all Europe, and the claim we will not dispute. Certainly a more magnificent outlook, combining the attractions of a land with a history so rich and varied, of so majestic a volcano, of so fair a sky, and of a sea so beautiful as on that bright sunny April day, never met our gaze.

And then the view of Etna at sunset, from the terrace of the Hôtel Timeo, and again when its cone was lit up by the rising sun, were memorable scenes. The volcano was also kind enough to flame up at night, the light of the glowing but subdued volcanic fires at the bottom of the crater being reflected in the darkness upon the clouds of steam hovering above.

The fires of Etna have subsided, only to be succeeded in that beautiful island by a far more terrible social upheaval; the burden of agrarian wrongs, inflicted by the wealthy landholders, and of the too heavy taxes causing a sudden and widespread volcanic uprising on the part of the downtrodden peasants. Let us hope that by timely concessions and patient readjustments of the relation between landlords and tenants a calm as serene and pervasive as to outward appearance at least reigned over the fair island a few years ago, may speedily return.

THE Rev. Lorimer Fison explained the classificatory system of relationship to the British Association by an examination of the descendants of two brothers and two sisters to the third generation. The Fuegian terms of relationship were taken in the first place as an example of the system. These divide the sexes in any one generation into groups of non-marriageable persons and other groups of marriageable persons. Next, the same relations and their descendants in an Australian tribe were taken, when precisely the same groups appeared as the result of the division of the community into two exogamous intermarrying divisions. It was inferred that wherever the classifactory terms appeared these divisions had existed in the past.

THE LESSON OF THE FOREST FIRES.

By BELA HUBBARD, LL. D.

VOYAGERS on the upper lakes in August last were involved in clouds of smoke which settled over the waters. These were often so dense as to render navigation dangerous and to occasion frequent collisions. They obscured the sun, which appeared a dull red ball in the sky. This smoke extended as far east as the Atlantic and south to Georgia. The cause was soon apparent: forest fires were raging in the lands about the lakes.

By these fires in lower Michigan property to the extent of thousands of dollars was destroyed; in the Upper Peninsula the burned area is reported at over one thousand square miles.

But these devastations were insignificant compared with those in Wisconsin and Minnesota, in each of which States the losses amount to many millions of dollars. In Wisconsin the areas burned over ranged from fifty to one hundred and forty miles in extent. Individual lumbermen lost in standing pine from ten thousand to five hundred thousand dollars. All this was accompanied with the destruction of entire villages and crops as well as great loss of human life. A witness reports, "The bodies which dot the heated and black expanse give the scene the appearance of a battlefield."

From Minnesota the news is even more appalling. Between Pine City and Carleton, a distance of one hundred and thirty miles, whole towns were swept out of existence. In one alone, Hinckley, at least two hundred people perished. Nineteen villages are wholly or partially destroyed, and many million feet of lumber. It is fairly computed that in this State alone five thousand square miles in area have been thus devastated. Minnesota contains about seventy thousand square miles; supposing two thirds of this area to be timbered land, one may count on the fingers of his two hands how many years of such devastation will deprive this State of every vestige of its timber.

Terrible as has been the destruction from forest fires in 1894, the phenomena to which it has borne witness have been by no means unprecedented in our history during the last half century. I will recall those of a single year only.

The present generation can not have forgotten the year 1871, made memorable by the great fire in Chicago, preceded by forest fires in Wisconsin and Minnesota and followed by similar fires in Michigan. From July to November, a period of five months, the rainfall in the latter State did not exceed six inches, and the entire precipitation of the year was only two thirds the normal amount. Early in October disastrous fires overspread portions of Wisconsin

and Minnesota, burning over three thousand miles of territory. On the 8th of October occurred the great fire which consumed a large part of Chicago. On the same night the cities of Holland and Manistee, in Michigan, were laid in ashes, and during the week succeeding came news of devastating fires in other parts of the State. The new county of Huron was almost entirely swept over, and a large part of Sanilac County. Nearly all the villages on the Lake Huron coast were destroyed, and at least five thousand inhabitants left houseless. Houses, fences, crops, timber, all were burned; and many people perished, being unable to escape the rapid march of the flames and smoke. Not less than two thousand square miles of country, wholly or partially timbered, were completely burned over in Michigan during this disastrous year. The Lower Peninsula contains forty-four thousand square miles. If we estimate about one half, or twenty thousand square miles, as timbered, it would require but ten such fires as that of 1871 to sweep the State clean.

Forest fires nearly as disastrous have occurred in other States and other years, but these will suffice for our purpose.

What is the origin of these forest fires? Are they preventable? Upon whom lies the responsibility? These questions open a large field of inquiry and involve the whole subject of our forest system, or want of system, and management good or bad of our woodlands, from the first settlement of the country. This is too large a subject to be treated as it deserves in a single paper, but even a brief consideration may make clear facts of the greatest scientific importance and serve to inculcate a lesson which can not be too strongly enforced.

The extent and magnificence of the forest growth of the United States at the beginning of our existence as a nation surpassed that of any land of equal extent on the globe. In the number of species and the size of its trees, both deciduous and evergreen, it exceeded by five times that of Europe. Such a forest spread almost unbroken from the Atlantic to the Mississippi. An equally dense forest, mostly conifers, and many of a size before unknown, occupied the Pacific slope; while between stretched an almost treeless region comprising nearly half the territory of the United States. What a treasury of wealth belonged to the new nation in its woodlands if properly husbanded! But to its first possessors these were an incumbrance, to be got rid of as speedily as possible, in order that place might be made for another source of national wealth—agriculture.

Since that early period how great has been the change! The forest area, which seemed to its first possessors so vast, and such an obstacle to civilized progress, has in a single century almost disappeared.

Computations have been made, from time to time, by competent persons, including our efficient forestry chief, Prof. Fernow, of the number of cubic feet of wood of all kinds annually used by our people for all purposes. Into these I do not propose to enter. It must suffice to say that the total annual consumption has been variously estimated at from four to eight million acres of woodland. Forest fires are responsible for ten million acres more, or nearly double all other causes combined.

The United States east of the Mississippi contains about five-hundred million acres. Assuming one half to be timbered land, and that ten million acres cover the actual annual consumption and destruction, our woodlands will practically last only another quarter of a century.

A peculiar feature about this excessive depletion of our forests is the wasteful and improvident manner in which it has been accomplished. Nowhere else has such waste been witnessed. Lands have been so cheaply obtained, and their resources have appeared so boundless, that it seems hardly to have occurred that there could be any limit. Not only have no means been resorted to for renewal of the woodlands, but all who have had to do with the forests—whether lumber barons or poor settlers—alike have looked to personal gain, with no regard to the future. Especially has this been the case with lumbermen in the pine districts. A noble pine tree is felled; one, two, or three saw logs are cut off, and the remainder left to litter the woods and to decay. Nor have the unsold Government lands escaped. Universally have these been plundered, as if Uncle Sam had no rights in his forest domain which his family were bound to respect. Nor has it been easy, if possible, to exact justice against plunderers, for juries will seldom convict, and are likely themselves to be *particeps criminis*. Besides, the law, or at least custom, allows settlers to take whatever timber they need for their buildings and fences, and the question is seldom asked where sawmills in a sparse community obtain their supplies.

Forest fires have accompanied the lumbermen, and it will be observed that the most extensive and disastrous ones have occurred in the pine districts. Nature's records show that before the advent of the white settler fires often swept the prairies and oak openings, and doubtless the peculiar character of these is largely due to this fact. The Indians were hunters, and the needs of the chase were met by the annual burning of the grass, which harbored game while it hindered the chase. Usually the damage to timber thus occasioned was but little, though in the course of years many a fine tree succumbed to repeated attacks. But the Indians never ruthlessly destroyed the woodlands. The white hunter, too, who roamed the woods before they were occu-

pied by the tiller of the soil, left behind him no disastrous traces of his presence, or, if a conflagration sometimes followed his camp fires, it occurred but seldom, and was never intentional. Both the aboriginal wood-dweller and his venatic successors looked upon the forest as the gift of the Great Spirit, to be reverenced by man as a sign of the bounty of a beneficent Creator, and not to be wantonly desecrated.

The practice of burning the old and dry grass in unoccupied lands, in order that a younger and more tender growth may give pasture to cattle, is still common in some of our States, and its results, though of benefit to a few, are disastrous to the general welfare. In Florida the cattle men have long been omnipotent. They have sway in the Legislature, which enacts laws to suit their wishes, even to the extent of prohibiting towns and villages from passing ordinances to prohibit the running at large of cattle. A considerable portion of the State is thus annually burned over. Nor is it the grass alone that burns, but fire communicates to the pine trees, thousands of which yearly succumb. Meantime fences must be maintained to keep out cattle commoners, only to be often burned in their turn. Worse than all, the *humus* in the sandy soil is burned out, and the future wealth and resources of the State are destroyed, to privilege a few, whose entire interests are not a thousandth part in value of the ruin they accomplish. At this day and everywhere may be encountered tracts of utterly barren and worthless land, in the midst of comparatively fertile, whose fertility has been thus destroyed. In northern California similar aggressions are committed by the sheep-herders, and the Government reserves have to be protected by the army, acting as patrols.

There is another aspect more important even than the value of the pecuniary loss to the country from the extraordinary and rapid consumption of its forests, and which still more strongly concerns the future of the nation. I refer to the effects of deforestation upon the climate and soils.

Although there is not entire agreement among scientists as to the effect of the removal of forests upon the climate, and especially the rainfall, the following propositions seem to be well established:

1. That the temperature is *hotter* in *summer* and *colder* in *winter* than when the country was covered with forests. This is a natural result of exposure of the soil to more active radiation and consequent frost.

2. The *winds have a more uninterrupted sweep,* and so the country is both dried up and refrigerated.

3. The *rainfall* is either *less in amount,* or its advantages are to a great degree lost. Forests retain the moisture that falls and do not allow it to go to waste.

4. The *humus* in the soil, and the soil itself on the hills and slopes, are washed away by the rains, and carried to the lower lands and to the rivers, a large part being lost altogether.

Abundant examples from the Old World might be adduced to fortify this position, and to show how numerous and great have been the changes from fertility to barrenness by the neglect to heed the warnings of Nature. But these are so well known to even the unscientific traveler and reader that I forbear.

Most of us who have lived in America, even a single generation, will recall many facts that warn us how closely we are following the path that has led older countries to ruin. Streams with which we were familiar in childhood have shrunken or dried up. Springs have failed; the hills are bare and desiccated. How different the aspect of the older settled portions from what they appeared to eyes that beheld them less than a century ago! How real this description by Bryant:

> "Before these fields were shorn and tilled,
> Full to the brim our rivers flowed;
> The melody of waters filled
> The fresh and boundless wood;
> And torrents dashed, and rivulets played,
> And fountains spouted in the shade."

Now these woodlands no longer echo the song of the poet, and the melody of waters is exchanged for the rush and roar of the torrent.

Droughts are now the rule rather than the exception. Our pastures dry up and are of little service for several weeks during the year. The more tender fruits can not be successfully grown where abundant crops greeted the days of old. Many of the most hardy trees and shrubs are killed by the depth to which frost penetrates the soil.

So great and so indiscriminate has been and continues to be the destruction of the protecting woods as to create in the statesman and the philanthropist a well-founded alarm lest our country be soon reduced to the condition of those regions of the Old World to which I have alluded.

Let us now inquire, What has been done in this country for the protection and preservation of the forests? In all the chief governments of Europe elaborate systems of forestry have long been established, to the end that the timber should be safe from all unnecessary destruction; that it shall be allowed to grow in situations where experience has proved its importance in the amelioration of climate and the preservation of the sources of river supply, and to secure the timber supply by replanting. In this country the general and State governments have only slowly

awakened to the importance of legislative control and the establishment of a forest policy.

The first important forest movement began with the enactment by Congress of the Timber Culture Act of 1873, having reference to the comparatively treeless region west of the Mississippi River. By this act the planting to timber of forty acres of land conferred the title to one hundred and sixty acres of the public domain. Even this law was in advance of real knowledge on the subject of forestry and of other conditions. It failed to produce the expected result, and after a few years was repealed.

The first act of Congress looking toward a definite forest policy, enacted in 1876, required the Commissioner of Agriculture to appoint "some man of approved attainments, with a view of ascertaining the annual amount of consumption, importation, and exportation of timber and other forest products; the probable supply for future wants; the means best adapted to the preservation and renewal of forests; the influence of forests upon climate; the measures successfully applied in various countries, and to report upon the same." In 1878 Mr. Franklin B. Hough made his first report, a volume of six hundred and fifty pages. He alludes to acts of Congress, passed as early as 1817 and 1827, under which reserves were made of such lands as had a growth of live oak and cedar for shipbuilding purposes; and that in 1854 the heads of the several land offices were authorized to investigate the repeated spoliations of public timber, to seize any timber found cut without authority, and to bring the offenders to the attention of the proper officers of the law.

Many of the States had before this taken hold of the subject, so far as to offer premiums for the planting, and in some cases exemption from taxes, especially to encourage the planting of trees along the highways, and also laws for the preventing of forest fires. In some of these States, as in Michigan, forestry as a science is taught in the colleges, though as yet no school of forestry has been established, as is done in every country in Europe, in which the general or local government are owners of woodlands.

State forestry associations have also been formed, Minnesota claiming the first, in 1878. In 1875 a National Forestry Association was formed, which since 1882 has met yearly, in widely separated localities. All these have been instrumental in arousing public interest, in issuing information on forest subjects, and in procuring legislation, especially regarding public reservations.

This movement has resulted in the enactment of a law by Congress permitting the setting aside, by proclamation of the President, of portions of the public lands, in the Western States and Territories, for permanent forest reservations. Previous to

1892 the General Government had made several extensive reservations, as parks, for preserving and opening to pleasure-seekers some of the natural wonders of our land, besides others for military purposes—viz.:

Yellowstone Park, Wyoming, containing	2,888,000 acres.
Yosemite National Park, California, containing	960,000 "
Sequoia National Park, California, containing	100,000 "
General Grant National Park, California, containing	3,000 "
Hot Springs National Park, Arkansas, containing	2,529 "
In all	3,953,529 acres.

During the administration of President Harrison several other and large reserves were added to these, so that we now have in all over seventeen million acres.

In the memorial presented to the President by the American Forestry Congress it is declared that the object of such reservations is to increase the sum total of the productiveness of our territory, the lands reserved being those that are unfit for agriculture, but capable, under wise management, of producing a greatly increased amount of forest products annually. Neither *bona fide* settlement of agricultural land, nor the right of prospecting for and opening mines, are to be interfered with. Demands for wood material are to be satisfied in a large and equitable manner; while it is sought to minimize the destruction by forest fires and wasteful and erroneous methods. The association further declared that such reservations *would no tsatisfy the needs* of forest protection unless the number is sufficiently large to *embrace practically all the remaining public woodlands.*

Several of the States have also recognized the importance of setting apart reserves of woodlands. In the great State of New York this sentiment had become so strong by 1872 that a commission was appointed to inquire into the expediency of legislation for vesting in the State the title to the timbered Adirondack region, and converting it into a public park. But public opinion was not sufficiently ripe, and the destruction of timber and absorption by corporations and individuals went on as before. It was not until 1893 that a bill was passed which provides for the acquisition by the State of the control of large districts, in addition to the half million already owned by the State, to be held in forest for the preservation of the sources of the chief rivers; for its future timber supply; for game preservation, and for the free use by the people for health and pleasure. Nearly one million acres have thus far been set aside. How far this legislation if perfected will prove valuable depends upon the wisdom of the management. In its inception there is the highest wisdom.

Notwithstanding the public interest awakened and the laws

enacted, both by the General Government and the States, very little has yet been accomplished toward the restriction of waste, the preservation of timber, protection from plunder, or prevention of forest fires.

Senator Dawes, in speaking of the invasion of the public lands, declared that "the ingenuity of the lawmaker has not yet equaled that of the spoliator." And even Mr. Fernow has pronounced, as his private opinion, that the United States has not yet reached the stage in the depletion of its forests when it is possible to carry out a really protective forest policy, and that this will not be accomplished until the country is reduced to the same condition of deforestation that the countries of the Old World had attained before remedial means were adopted. If this be true, we can only sit with folded hands and pray that this consummation may be speedily reached. Others, too, have joined the pessimistic strain, and argued that, "so long as the present conditions continue, the destruction of the forests is inevitable, and any policy of forest preservation is impossible."

I, for one, will not believe that our citizens are so blind to experience, or so indifferent or so powerless in this matter.

It is true that no government can prevent wasteful methods of lumbering so long as timbered lands are held as private property, and virgin forests can be bought at a rate so cheap that careless management will still leave a profit. But governments can control the process on land owned by them, by withholding the land from market, awaiting the time—not far distant—when the timber can be sold under such regulations as will make the most of its resources. If this were done, lumber owners would soon find their interest to lie in more provident methods; and increased values would make them saving of their resources. As to forest fires, since no plea of the public welfare avails to induce lumbermen to burn their *débris*, or to get rid of it in any way that is not directly repaid, and appeals to patriotism or a regard for the interests of their neighbors are unheeded, the strong arm of the law must be stretched out to compel.

Why this has not been done it is hard to say: common if not statute law gives redress, and holds the owner of land accountable to his neighbor for negligence that endangers him. Is there warrant, either in a court of law or of common sense, that the owner of land may cut his timber and pile up the remnants to dry and become combustible material, with danger to his neighbor's timber or other property in case of fire, without being held accountable to him for the damage? Probaby the legal aspect of the case is not well understood, and the results have been so long submitted to—perhaps because the injured are themselves similarly situated toward others, and therefore can

not come into court with clean hands—that sufferers have come to believe that such disasters are unavoidable.

It should be the practice of forestry associations to disseminate wholesome instruction on this head, and to present practicable plans for meeting the difficulties of the situation. Whatever the remedy suggested, it should ever be borne in mind that the owner of forest property, and especially corporations, have purchased for the purpose of converting the timber into money in the cheapest and most rapid manner possible, and that they are, as a rule, indifferent to the future of the region. They must also inculcate the principle that no legislation is effective, unless well-organized machinery is provided for its enforcement.

The mere holding of a man or a railroad liable in damages for such acts of carelessness and indifference as I have mentioned, and for setting fire to woods, is not sufficient. Infraction of the law should be made a criminal offense, punishable by the severest penalties. It should be made the duty of counties and townships to appoint fire wardens, as is provided in Pennsylvania and Maine—paid officials, who should exercise a vigilant watchfulness, and use extra precautions in exceptionally dry seasons. At such times the town should take upon itself the work of clearing away litter and all combustible material that add to the danger of fire. These should be burned or got rid of under constant inspection, at a time when the fire is not likely to spread. In case of a conflagration started, the wardens should be empowered when necessary to summon assistance. In France safety belts of trees not readily burned are planted on each side of the railway track where it passes through a pine forest. Roads, trenches, and cleared spaces are also so constructed as to prove a safeguard; the cost is paid partly by the authorities and partly by the landowners. Heavy penalties are imposed for kindling fires within certain prescribed limits.

Among many suggestions for a forest policy in the older States, that for Pennsylvania commends itself, in a bill now before the Legislature of that State. It provides that the Governor shall appoint a commission of two persons—a competent engineer and a practical botanist—who shall examine and report upon the important watersheds of the State, for the purpose of determining how far the presence or absence of the forest covering may affect the water supply; also the amount of standing timber, and a measure for securing timber supply in the future. The Pennsylvania Forestry Association, in recommending the bill, points out the fact that the vast forests once covering all the head waters of the principal streams are nearly gone; the splendid oak and other timber is almost exhausted; fires destroy two million dollars' worth of timber each year; timber thieves escape

unpunished; cattle kill the young growing timber, and no effort is being made to protect and renew the forest growth.

There is not a State in the Union that does not need to adopt similar precautionary measures, and these should be accompanied with some practical plan for management. It would be well for each State to have a single forest commissioner appointed by the Governor, whose duty it should be, in addition to the collecting of such statistics as above, to organize in each county and township a *system of fire wardens or patrols;* to see that special precautions are taken in cases of unusual peril; to ascertain the causes of fires and who is responsible, and to prepare evidence. He should be a man fully instructed and thoroughly competent, should be well paid, and should be held personally responsible. All officials appointed to such service should be *removed as far as possible from political affiliations,* should be under civil-service rules, and the position should be permanent during good behavior.

The adoption by the General Government of a national forest policy can not be much longer delayed, although Congress is very slow to act. In the sale of the treeless portions of the public domain the Government may require that a certain portion be planted in trees as soon as the proper conditions, means of irrigation, etc., exist, and that a certain proportion of the timbered land be kept in timber, the title to be dependent upon the stipulated conditions. Whether the United States will eventually come to adopt the methods of administration of the timbered lands in vogue in Europe is a question that time must determine. The country has as yet few persons that have been educated to forestry as a profession, and simple rules must suffice for the present. Both the General and State governments possess, in the right of eminent domain, the power to preserve and condemn where necessary such lands as it shall be decided the public benefit requires to be maintained as forest in perpetuity. Private rights must give way to public utility. The owners of premises which have become a menace must be made to contribute their proper share of the expense of protective measures and forest police.

A forest policy is at last taking form. A bill, introduced by Senator Paddock at the close of the Congress of 1892, provides in the first place for a survey to determine the extent and location of all forest lands, after which the President is to withdraw from sale all such lands, except those found to be more favorable for agriculture than for forest—these reserved lands to be transferred to the Department of Agriculture, where a Forestry Bureau exists.

It provides for a Commissioner of Forestry, to be appointed by the President, with consent of the Senate, who shall have con-

trol of all the forest reservations and timbered lands, subject to supervision of the Secretary of Agriculture, who shall appoint inspectors as assistants.

Each reservation to have one superintendent, who shall have full charge and control of the reservation for which he is appointed, and be responsible to the central bureau, and have such assistants as may be needed.

Rangers to be appointed by the Commissioner of Forestry to act as police, against trespass and fires, and to supervise the timber operations.

Full details of forest management are specified, into which I shall not here enter.

To create as quickly as possible an efficient protective service, the army may be employed for this purpose, as has already been done in the Yellowstone and California Parks. The system proposes a separate and complete administration, conducted by competent men under expert instruction, and, while the protecting of watersheds is of sufficient importance to warrant expenditure out of Government funds, the service should be made to pay for itself by the sale of surplus forest material.

The suggestion that the army be employed for policing the public forests is an admirable one. It has already done good service in this direction, and it will prove to be a constabulary force in which the country has full confidence. Military training has given the army a thorough organization and an *esprit de corps*, and it is free from political influence. Officers of the army made the best commissioners in Indian affairs which the country has ever had, and gained for themselves a just reputation for faithfulness, honesty, and courage. They will be equally good custodians of our forest domain. Were our army twice as large as it now is, it would be too small for war, but would find too little employment in time of peace, unless its services are used in civil channels. To supply qualities that are wanting for this particular service a chair of Forestry should be established at West Point, to give such instruction in forestry science as the case requires.

If the reforms here outlined, whether embodied in the Paddock bill or the McRae bill, or commended to our situation by foreign experience, shall be persistently urged by forestry and other associations, and the United States Government, heedful of the danger of neglect or delay, shall respond with promptness and energy and a proper regard for the future of the nation, a forestry policy will be inaugurated which will meet present requirements, and which may be extended and improved to serve all future needs.

Then the lesson of the forest fires will not have been learned in vain.

COPPER, STEEL, AND BANK-NOTE ENGRAVING.

By C. W. DICKINSON.

HOW few of the many people who are fortunate enough to have a dollar bill in their pocket think of it as a work of art! Two hundred years ago this piece of paper would have been of almost incalculable value, and have awakened an interest among the artists of that day which we can scarcely realize. Look at the portrait on the left of the face of the note. Here we have a beautiful specimen of pure line engraving—much better work than most of that done by some of the old masters and now considered classic. Then there are on both face and back the fine, delicate effects of light and shade produced by the ruling machine and geometrical and cycloidal engraving lathes. Further than this can be seen elegant designs in scroll work and lettering.

This may be a piece of "the root of all evil," and we know it is often "filthy lucre," only worth one hundred cents to us, yet it may be profitable to inquire as to how it is made.

Steel and copper plate engraving does not, as is generally supposed, owe its origin to the woodcut, but to the chasing on goldsmith's work. Look at any article of jewelry ornamented with incised designs, and there will be seen the true origin of line engraving; and although this work was not done—as was the steel or copper plate engraving—for the purpose of producing copies by printing, still it was by this engraving on jewelry that the art of printing from an incised line was, like a great many other good inventions, accidentally discovered.

The goldsmiths of Florence, in the middle of the fifteenth century, were in the habit of ornamenting their works by means of engraving, after which they filled up the hollows produced by the graver with black enamel (made of silver, lead, and sulphur), the result being that the design was rendered much more visible by the contrast of the enamel and the metal.

An engraved design filled up in this manner was called a *niello*, and our modern door plates are really *nielli* also, for in these, too, the engraved lines are filled with black. The word *niello* comes from *nigellum*, and simply refers to the color of the enamel.

While a *niello* was in progress, the artist could not see the effect of his work so well as if the enamel were already in the lines; and, on the other hand, he did not like to put the enamel in the unfinished engraving, as, when once it was set, it could not easily be got out again. He therefore took a sulphur cast of his *niello*—in progress—on a matrix of fine clay, and filled up the

lines in the sulphur with lampblack, thus enabling himself to judge of the effect of his engraving thus far.

At a later period it was discovered that a proof could be taken on damp paper by filling the engraved lines with a certain ink and wiping it off the surface of the plate, sufficient pressure being applied to make the paper go into the hollowed or engraved lines and bring the ink out of them. This was the beginning of plate printing, but nobody at first suspected the artistic and commercial importance of the discovery. The *niello* engravers thought it a convenient way of proving their work, as it saved the trouble of the sulphur cast, but they saw no further into the future. They went on engraving *niello* just the same, to ornament jewelry and furniture; nor was it until the next century that the new method of printing was carried out to its great and wonderful results. Even in our day the full importance of it is only understood by persons who have made the fine arts a subject of special study.

The earliest engravers on metal for the purpose of multiplying by printing, of which we have reliable information concerning names and dates, were the German artists, Martin Schongauer and Albert Dürer. Schongauer was the earlier artist of the two, as he died in 1488, while the date of Dürer's death is 1528, just forty years later.

Schongauer, though a generation before Dürer, was scarcely inferior to him in the use of the graver, but Dürer has a much greater reputation—due in a large measure to his singular imaginative powers. Schongauer is the first great engraver who is known to us by name, although he was preceded by an unknown German master who is called "the Master of 1466." He had Gothic notions of art, but used the graver skillfully in his own way; conceiving of line and shade as separate elements, yet shading with an evident desire to follow the form of the thing shaded, and with lines in various directions.

Schongauer's art is a great stride in advance, and we find in him an evident pleasure in the bold use of the graver; his outline and shade were better blended, the shade being done more by the use of curved lines than is found in the works of those before him.

Dürer continued Schongauer's curved shading with increasing delicacy and skill, and as he found himself able to perform feats with the graver which amused both himself and his buyers, he overloaded his plates with quantities of living and inanimate objects, each of which he finished with as much care as if it were the most important thing in the composition.

The engravers of those days had no conception of any necessity for subordinating one part of their work to another; they

drew—like children—first one object and then another, and so on, until the plate was furnished from top to bottom and from right side to left.

In Dürer, all objects are on the same plane! In his Saint Hubert, the stag (Fig. 1) is quietly standing on the horse's back,

Fig. 1.—Dürer's Saint Hubert.

with one hoof on the saddle, and the kneeling knight looks as if he were tapping the horse on the nose while bowing before the crucifix. The artist seems to have noticed the mistake about the stag, for he put a tree between us and the animal to correct it, but the stag is on the horse's back nevertheless.

There is no reason why steel engraving should be used only to

translate painting. The early engravers were often original artists who worked out designs of their own, but in course of time a commercial reason prevailed over originality. It was found that a well-known painting assured the sale of an engraving from it beforehand, whereas an engraving which stood entirely on its own merits came into the world without advantages, and had its own way to make. Besides this, the engraver who copied a picture saved himself all the trouble of thinking out and composing the design which he found ready to his hand.

This is why we have to-day so very few original artists in steel engraving and etching; although there has been a great revival of etching in the last twenty years, especially in Europe, and many artists have acquired great skill in this mode of engraving (Hayden in Europe and James D. Smillie in America being considered the best in their respective countries), it has nearly all been copying.

We can not but deplore this subordination of engraving to painting, and when we look back to the great engravers of past times, who composed and invented their own works, it is with a feeling of regret that they have left so very few successors; for steel engravings have found a place in the hearts of the people of this country that no other class of art can ever replace.

Before leaving this subject of early engravers and their works, let us look at the influence exerted upon them by Raphael and Rubens.

In Italy, Marc Antonio was considered one of the great artists and copied Dürer, translating more than sixty of his woodcuts in metal (for Dürer was also a wood engraver).

It is one of the most remarkable things in the history of art that a man who had trained himself by copying northern work—little removed from pure Gothicism—should have become, soon afterward, the great engraver of Raphael, who was much pleased with his work and aided him by personal advice. Yet, although Raphael was a painter and Marc Antonio his interpreter, we must not infer that engraving had as yet subordinated itself to painting.

Raphael himself evidently considered engraving a distinct art, for he never once set Marc Antonio to work from a picture, but always gave him drawings, which the engraver might interpret without going outside of his own art; consequently, Marc Antonio's works are always original engravings. A school of engraving was thus founded by Raphael through Marc Antonio, which cast aside the minute details of the early schools for a broad, harmonious treatment.

Another school — which marked a new development — was known as the engravers of Rubens. That great painter under-

stood the importance of engraving as a means of increasing his fame and wealth, and directed Vorsterman and others, as Raphael had directed Marc Antonio. Rubens's theory of engraving was that it ought not to give accurately the local color of the picture, which would appear wanting in harmony when not associated with the hues of the painting; and it was one of his anxieties so to direct his engravers that the result might be a fine plate independent of what he had painted. To this end he also helped his engravers by drawings, and he sometimes went so far as to indicate what he thought the best direction for the lines.

Previous to the year 1830 only copper plate was used by engravers, because up to that time it was not thought possible to make steel soft enough to cut easily and smoothly. The first plate produced—that could be used—was called "silver steel." Later there was manufactured the "Prussian steel" plate, which was a slight improvement in fineness of grain. Other and greater improvements followed, until now steel has almost entirely superseded copper.

Decarbonated cast steel is used for general engraving purposes and must be of very fine grain, and very soft as compared with natural cast steel. The plates are rolled out from bars of steel in its natural state, then decarbonated and cut to about the size desired, leaving enough margin to square the edges, which are finished with a wide bevel. After the plate has been cut to size, it is flattened by laying it upon a copper anvil and hammering with a wooden mallet until it is as flat as is possible to get it by that process. A uniform thickness and perfectly flat surface are then given to the plate by grinding—sometimes by hand, usually by machine—the latter process being the better, as it is the more perfect in its results. By grading the stones used in this grinding from coarse to fine, the plate is left ready for the final finish, which is given by burnishing and rubbing with very fine emery leather made for the purpose, from the finest grade of emery that can be had.

Copper plate is still used to a considerable extent for visiting cards, invitations, and such small work as calls for only a limited number of impressions, for copper will not stand nearly as much wear as steel, often wearing out in one thousand impressions, while ten or even fifteen thousand can be taken from steel, and, if the plate is hardened, as is often done, one hundred thousand have sometimes been pulled before the plate has entirely given out. Copper is also used in some cases for the cheaper classes of picture work, such as book illustrations, but it is usually coated with steel or nickel by precipitation, this facing taking the wear instead of the copper.

The tools used in steel engraving are about the same as those

used on wood, excepting the heavier wood scaupers, as they are called (chisels or gouges would perhaps give a better idea of what they are). These could not be used on steel, because the hand of the artist could not force them through the line to be cut; so a more delicate graver is used, and a great many cuts are taken in the same line, thus making it broader and deeper by degrees.

There are several kinds of picture engraving and etching, the most prominent of which are aquatint, mezzotint, stipple, rouletting, and line engraving.

Aquatint is a kind of etching used to get the effect of drawings in India ink, and at one time it was greatly made use of in rendering the drawings of Paul Sandby and our early water-color painters, and particularly prints for drawing-books.

There are many ways of preparing a plate for this work, but the following is the best: Have three different solutions of rosin in rectified alcohol, making them of various degrees of strength, but always thin enough to be quite fluid, the weakest solution being almost colorless. First pour the strongest solution on the plate, which has previously been very carefully cleansed from all oil and grease that would prevent the acid acting upon the steel. When this strongest solution dries it produces a granulation, and you may now bite or corrode the steel with acid through these granulations for your darker tones, stopping out with a varnish made of sealing-wax dissolved in alcohol where the acid is not to operate, or the acid may be applied with a brush where the dark tones are desired. After cleaning the plate as before you proceed with the weaker solutions in the same way; the weakest giving the finest granulations for skies, distances, etc.

The process requires a good deal of stopping out and some burnishing and scraping for the high lights in finishing.

Another style of aquatinting is done by placing a clean plate in an air-tight box where there has been a dust of rosin circulated by means of a bellows attached to the box. The finest of the particles of rosin are allowed to settle on the plate, which is then heated until this dust of rosin sticks to it where it has fallen. The acid is now put to work as before. This gives an even tint something like the other process, the difference being in this case that the acid bites the plate between the particles of rosin, making a black around a white, whereas in the first process the acid acts through the granulated rosin, producing a black surrounded by a white. An impression of either of these plates, taken in the condition the acid leaves them, would resemble a tint or wash of color on paper.

David Allan engraved his celebrated illustrations of the Gentle Shepherd in this manner. This style of engraving has now

gone almost entirely out of use, having been—like engraving in imitations of drawings in chalk or pencil—in a great degree superseded by lithography.

Mezzotint is said to have been invented by Prince Rupert, or by Leivis Siegen, a lieutenant in his service, in or about the year 1611, and to have been suggested by the rust on a weapon which a soldier was cleaning.

The plate is prepared (before any design is made upon it) by means of an instrument or tool called the "rocker" (see Fig. 2). This "rocker" is rocked to and fro upon the plate in all directions, and the teeth in the sharp, beveled edge of the tool make a small dent in the copper or steel and raise a corresponding "burr." The whole plate is gone over with this instrument about eighty times before it is in a fit condition to be worked upon. When sufficiently prepared it presents a fine, soft-looking, and perfectly even grain, and if in this state a proof is taken from it by the usual process of plate printing the result is the richest possible black.

FIG. 2.—THE ROCKER.

On this plate, after a tracing has been transferred, the engraver goes to work, with tools called "scrapers" and "burnishers," working from dark to light by removing the dents and burrs, and exactly in proportion as he removes them the tint becomes paler and paler, those parts most smoothed being the lightest and the part the least operated on producing the deepest shadows. As the process is from dark to light, the engraver has to be very cautious not to remove too much of his grain at once, for once he has it too light it would be impossible to restore the color without destroying the surrounding lights. He proceeds from dark to half dark, from half dark to middle tint, from middle tint to half light, and from half light to light. When the work is good the result is soft and harmonious, well adapted to the interpretation of some painters, but not of all.

More than one hundred engravers in mezzotinto employed themselves on the portraits of Sir Joshua Reynolds, and the best of their works are now valued as the classics of the art which is connected with the name of Reynolds, just as line engraving is connected with that of Raphael.

In engraving in "stipple," which was much in vogue in the

end of the last century, the drawing and effect are produced by small dots in place of lines (Fig. 3).

These dots follow at first the outlined shades, starting with a double dot where the darker shades are desired. Smaller dots are placed close to these double dots on the side nearest the largest space. Lights are had by using very fine dots, and high lights by leaving them out altogether.

Ryland, Bartolozzi, and Sherwin excelled in this style of engraving. It is well suited for portraits; several of Rasburn's have been capitally engraved in "stipple" by Walker. It involves much more labor than any other kind of work in this line of fine arts, except line engraving, and is now little practiced.

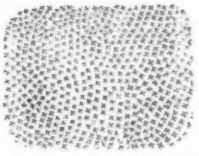

FIG. 3.—STIPPLE.

Rouletting is done with a tool very much like those sold on the streets nowadays for cutting glass. A small hardened steel wheel is set in the end of a pencil-like handle (Fig. 4). On the edge of this wheel is cut the pattern desired by the artist—notches, lines, dots, or whatever may be called for by the subject to be treated. This wheel is rolled on the plate, leaving an indentation like the marking on its edge.

This peculiar style of engraving is used, in connection with others, where particular effects are desired, pencil and charcoal lines being imitated in this way, thus securing that beautiful sketchy style better than can be obtained by any of the others.

FIG. 4.—THE ROULETTE.

We now come to consider line engraving, the most important as well as the most difficult of them all, and the only kind that can be used successfully in bank-note work (Fig. 5).

It is so called because the effect is produced by a combination of lines or interrupted lines. The more harmonious these lines are in shape or direction, spacing, and texture, the better will be the effect and the more valuable the work. Because of the requirement of this accurate spacing and harmony of texture mechanical as well as artistic skill is called for in producing a first-class line engraving. Many good artists in other lines fail in this art for want of this mechanical skill.

Line engravings have always ranked the highest in this branch of the fine arts, some people preferring them to water colors or oil paintings.

As stated before, this is the only picture work that can be used successfully in bank-note work, for it is much more difficult to imitate, and consequently gives greater security, being less liable

to be counterfeited. This is so also because a line cut with a graver is smooth, sharp, and clean, whereas an etched or bitten line is ragged and rough.

Line engraving is the most expensive, for it takes much more time to produce a picture by this process than by any other. Some of the large plates by the late James Smillie, father of the James D. Smillie mentioned earlier in this paper, and who was the best artist of his time in America, cost as high as ten thousand dollars, and took the greater part of two years to complete.

Fig. 5.—Line Engraving.

Bank-note Engraving.—For the sake of convenience we will divide bank-note engraving into two classes: 1. Lettering. 2. Picture and scroll work.

Lettering may be described under three heads—large lettering, such as bond titles; small lettering, like that done on coupons, cards, and tickets; and script or writing. Some engravers can do good work in all of these branches of lettering, but in large establishments each man is kept employed at that style in which he excels.

In bonds and stock certificates the titles and script are usually done on the plate from which they are to be printed, but there is a lot of small work, common to jobs of that kind, which is done on what are called "dies" or "bedpieces," and transferred from the rolls to the plates. This will be more fully described later.

In large lettering a drawing of the outline of the letters is made on paper to get the shapes, curves, and spacing correct. A tracing of this outline is then made on gelatin, and, after filling this with vermilion, a thin coating of wax is laid on the plate and a transfer of the gelatin tracing put on the wax. Next the outline is carefully marked through the wax on to the plate; the wax is taken off and the artist is ready to begin his cutting.

Lettering on bank notes, if there is to be more than one note on a plate, is engraved on "dies" or "bedpieces" and transferred to the plate. This insures the exact duplication of the material of each of the notes, and also makes it possible to reproduce and retouch the work at any time.

Picture and Scroll Work.—Picture and scroll work is the most expensive connected with the bank-note business, and is divided into three classes, viz., scroll, portrait, and vignette engraving. It is a very unusual thing to find a man who is a first-class artist in more than one of these branches, and there are none that are even good in all three. This is one of the safeguards of the

end of the last century, the drawing and effect are produced by small dots in place of lines (Fig. 3).

These dots follow at first the outlined shades, starting with a double dot where the darker shades are desired. Smaller dots are placed close to these double dots on the side nearest the largest space. Lights are had by using very fine dots, and high lights by leaving them out altogether.

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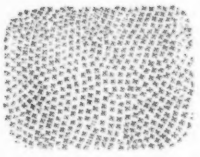

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This peculiar style of engraving is used, in connection with others, where particular effects are desired, pencil and charcoal lines being imitated in this way, thus securing that beautiful sketchy style better than can be obtained by any of the others.

FIG. 4.—THE ROULETTE.

We now come to consider line engraving, the most important as well as the most difficult of them all, and the only kind that can be used successfully in bank-note work (Fig. 5).

It is so called because the effect is produced by a combination of lines or interrupted lines. The more harmonious these lines are in shape or direction, spacing, and texture, the better will be the effect and the more valuable the work. Because of the requirement of this accurate spacing and harmony of texture mechanical as well as artistic skill is called for in producing a first-class line engraving. Many good artists in other lines fail in this art for want of this mechanical skill.

Line engravings have always ranked the highest in this branch of the fine arts, some people preferring them to water colors or oil paintings.

As stated before, this is the only picture work that can be used successfully in bank-note work, for it is much more difficult to imitate, and consequently gives greater security, being less liable

to be counterfeited. This is so also because a line cut with a graver is smooth, sharp, and clean, whereas an etched or bitten line is ragged and rough.

Line engraving is the most expensive, for it takes much more time to produce a picture by this process than by any other. Some of the large plates by the late James Smillie, father of the James D. Smillie mentioned earlier in this paper, and who was the best artist of his time in America, cost as high as ten thousand dollars, and took the greater part of two years to complete.

FIG. 5.—LINE ENGRAVING.

BANK-NOTE ENGRAVING.—For the sake of convenience we will divide bank-note engraving into two classes: 1. Lettering. 2. Picture and scroll work.

Lettering may be described under three heads—large lettering, such as bond titles; small lettering, like that done on coupons, cards, and tickets; and script or writing. Some engravers can do good work in all of these branches of lettering, but in large establishments each man is kept employed at that style in which he excels.

In bonds and stock certificates the titles and script are usually done on the plate from which they are to be printed, but there is a lot of small work, common to jobs of that kind, which is done on what are called "dies" or "bedpieces," and transferred from the rolls to the plates. This will be more fully described later.

In large lettering a drawing of the outline of the letters is made on paper to get the shapes, curves, and spacing correct. A tracing of this outline is then made on gelatin, and, after filling this with vermilion, a thin coating of wax is laid on the plate and a transfer of the gelatin tracing put on the wax. Next the outline is carefully marked through the wax on to the plate; the wax is taken off and the artist is ready to begin his cutting.

Lettering on bank notes, if there is to be more than one note on a plate, is engraved on "dies" or "bedpieces" and transferred to the plate. This insures the exact duplication of the material of each of the notes, and also makes it possible to reproduce and retouch the work at any time.

PICTURE AND SCROLL WORK.—Picture and scroll work is the most expensive connected with the bank-note business, and is divided into three classes, viz., scroll, portrait, and vignette engraving. It is a very unusual thing to find a man who is a first-class artist in more than one of these branches, and there are none that are even good in all three. This is one of the safeguards of the

bank-note business, as no one man can finish a note completely, but must find some one to help him.

The dies and bedpieces mentioned above are pieces of annealed steel—that is, steel that has been softened without decarbonizing—on which work has been engraved that is to be used several times on the same "job," or for a number of different plates. These dies, after "proving," are hardened by heating in cyanide of potassium, which is used in all hardening processes connected with the bank-note business. After these dies are hardened a roll made from very soft steel is rolled over the work under a pressure of from six to twenty tons to the line. This pressure is had by means of a machine called a transfer press,

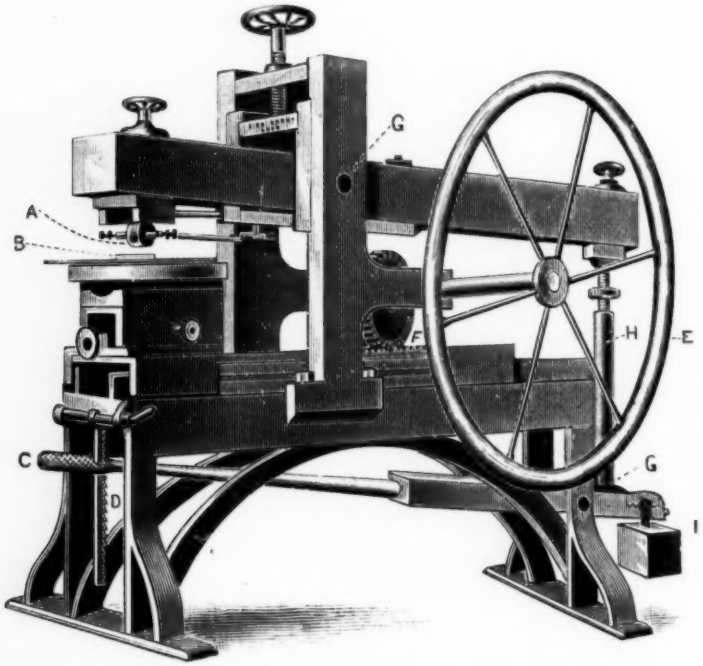


FIG. 6.—TRANSFER PRESS. A, Roll in carrier; B, die or bed piece; C, foot lever; D, rack to fasten lever down; E, side wheel by which bed of press is moved back and forth; F, rack and pinion connecting them; G, G, fulcrum pins of upper and lower levers; H, connecting rod between two levers; I, counter balance.

which, by a combination or compounding of levers, multiplies the pressure exerted by the operator from one hundred to one hundred and fifty times (Fig. 6).

By means of the large wheel on the side of the press, the shaft of which is geared into a rack fastened to the bed of the press, the roll, with this tremendous pressure still on it, is rolled back and forth on the die until the fine grain of the soft steel is forced into every line of the work. This gives the reverse of the die on

the roll. Even the finest and faintest scratch of a diamond point can be taken up this way and retransferred to another piece of steel and printed to the paper, so little is lost in the operation.

The roll is now put through the same process of hardening previously used on the die, and we are then prepared to make a great many duplicates of the original. One hundred or more facsimiles of the die can be made in less time than it took to produce the original. For instance, it takes a picture engraver about six weeks to engrave a portrait like that of Martha Washington on the left of the one-dollar United States note, and it can be reproduced in fifteen minutes by means of the transfer press and a roll taken from the original die.

Imagine, if you can, the work it would be to engrave by hand the two hundred postage stamps that are usually put on the plate from which they are printed, or the forty or fifty coupons of a bond. An endless job, you say, and yet that is just what would have to be done if it were not for the transfer press. And not only is it possible to thus readily multiply facsimiles of the original, but the reproductions are exact in every respect and detail, excepting the almost imperceptible loss in the process, which is natural and unavoidable.

Transferers work from a paper model made with prints from the original dies, which are very carefully put together in such a way as will give a very good idea of the effect of the finished work. These models are also submitted to and accepted by the party for whom the work is to be done.

After the plate is transferred it shows hollows around the work, made by the pressure of the roll, which must be brought back to a flat surface again; otherwise a clean proof could not be taken. These hollows are flattened by first carefully marking the outline of the work on the back of the plate, by means of "calipers" made for the purpose, then laying the face of the plate on a polished hardened-steel anvil and hammering around the outline. All scratches, guide lines, and marks that have been used by the transferer are then removed by burnishing the surface, and the plate is ready for the engraver's hands, for there is always some flourishing and finishing to be done before the plate is ready for the printing press.

Plate printing is the opposite of block or woodcut printing in this respect: The line that is to print the color is cut into and below the surface in plate work, and may be so fine that it can not be seen without the aid of a strong magnifier, and yet print perfectly clear and unbroken, while in block the line is left standing and must have some appreciable thickness. For this reason wood engraving can never be as delicate as plate, for it could not

be printed. And not only does an impression from plate excel in delicacy but also in force and depth of color.

There never was and never will be a woodcut line having the power of a deep line in a plate, for, in an impression from wood, the print is only a blackened surface of paper, whereas that from plate is a cast with an additional thickness of ink, for the damp paper is forced into the line and brings out the ink upon its embossed surface.

Plate ink is soft and thin as compared with that used for surface prints, and the body of it is ground carbon mixed with oil for black; and colored ink is made from white lead mixed with dry colors and very finely ground in oil. Some inks are much more wearing on the plates than others, green being about the worst in this respect.

Retouching, or "re-entering," as it is called in the trade, is done by re-entering the roll upon the lines of the transferred work and putting the pressure on, as in the original transfer. This sharpens and restores the line, making it print as good as when new.

The very best linen fiber paper is used in printing bank notes, bonds, stock certificates, etc., and it is dampened before printing to make it more pliable, and it also takes the ink better in this condition. After printing the sheets are placed on racks in a drying room heated by steam. When they are thoroughly dry they are found wrinkled and curled, so they are placed between Bristol boards and put under a hydraulic pressure of several hundred tons and kept there for a few hours, then taken out ready for trimming, numbering, and shipping. Each time the impressions are handled they are counted and kept track of, good or bad, so there shall be no possibility of loss or theft.

There are some very delicate machines used in bank-note work, known as ruling machines and cycloidal and geometric lathes. The straight and curved line ruling machine is used in making the background of portraits and vignettes, shade and ruled faces of letters, background of panels, and is capable of ruling three thousand six hundred lines to the inch with great perfection and regularity, but is seldom set as fine as this.

The cycloidal ruling machine is more complicated than the plain line ruler, having from one to four "eccentrics," or "cams," in connection with the forward and back movement of the bed, and is used for producing fine tints to print over other colors and work. The principle of its operation is readily understood. A diamond point is arranged in the machine and given a circular motion by the action of the "cams." Now, while the point is revolving, let a forward movement be given to the plate and the line traced by the point will assume a form like this (Fig. 7),

which is called a "cycloidal line," and may be described as that line produced by a point revolving about a moving center. The shape of the curved line depends upon the relative rate of speed of the two motions, the circular one of the point and the forward

FIG. 7.—OPEN CYCLOIDAL LINE.

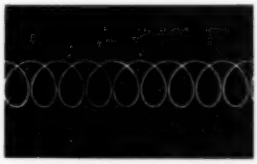


FIG. 8.—WIDE CYCLOIDAL LINE.

one of the plate. If the latter is comparatively slow, the cycloid will take this shape (Fig. 8); if still slower, the curves will cross each other instead of nearly touching. If the motion of the plate is comparatively rapid, the cycloid will take the form of Fig. 9, or one still more open.

By repeating these lines and causing them to overlap each other beautiful lacelike effects can be had, very difficult to imitate by hand (Fig. 10). The patterns can be varied almost endlessly.

Machine engraving of a far more intricate character is produced by the "geometrical lathe," which is one of the most delicate and complex machines ever invented (Fig. 11).

Americans have particularly distinguished themselves in mechanical engraving, and, in fact, it was one of our people—a Mr. Spencer, of Philadelphia—who introduced the "bank-note engraving machine" in the early part of this century. This machine, however, was very primitive, as it had but one "cam," and consequently was very limited in its possibilities as compared

FIG. 9.—CYCLOIDAL LINE

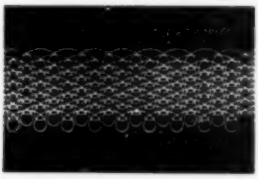


FIG. 10.—CYCLOIDAL PATTERN.

with those built in the present day, which have seven cams as well as other attachments not dreamed of by Spencer.

The geometrical lathe of the present day can not be described so as to be perfectly understood, but something of an idea of its working can be gained from the following:

A tool, mechanically sharpened and shaped, made of hardened steel, is used on this machine and is fixed solidly and immovably in a rest, or carrier, over the chuck of the lathe. If the chuck

were now revolved the result would be a plain circle cut into the steel plate; or, if the oval slide which is built into the chuck is in operation, the result would be an oval (Fig. 12).

The several cams, when in use, cause the "beds" (of which there are two, laid on rollers) to move back and forth, or to the right and left, as the operator may desire, once for each revolution. Now, suppose one cam was geared to revolve eight times while the chuck is revolving once, we would then have eight

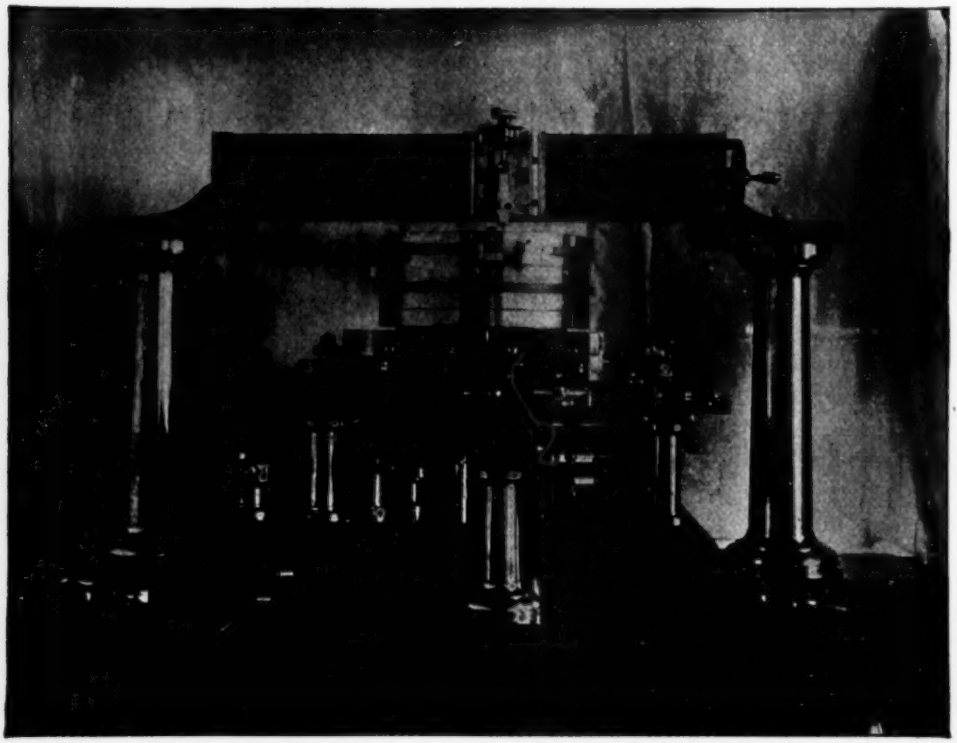


FIG. 11.—GEOMETRICAL LATHE. From "Paper and Press," by the kindness of W. M. Patton.

vibrations of the "bed," or eight waves in the line which was before a plain circle; therefore, we would now have an eight-sided figure, or a circle with eight bulges in it. (See inside line of the figure below.) If we now put another cam in motion, geared to revolve twenty-four times to the chuck once and the first cam's eight times, we would have twenty-four waves upon eight waves upon a circle, giving a line like that of the outside in the same figure (Fig. 13).

This has given us one of the many beautiful and perfectly geometrical forms that this wonderful and almost human machine is capable of producing under the management of a skilled artist.

Figs. 14 and 15 will show some of the more complicated designs and effects that may be had from one of these lathes. These look to be very complicated, but are, in reality, quite simple: Fig. 14 having but five continuous lines, including the two plain circles

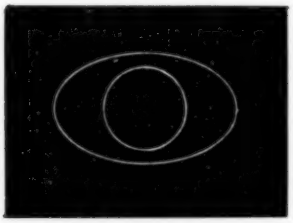


FIG. 12.—CIRCLE AND OVAL LINES.

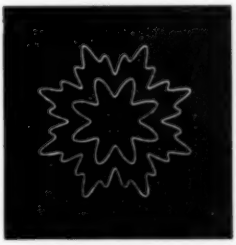


FIG. 13.—EIGHT WAVE AND 8-24 WAVE FIGURES.

of the outside, and Fig. 15 has but two; the beautiful effects being produced by the crossing and interlacing of the lines.

Some of the cuttings used for bank notes appear to have thousands of lines, but very few of them have more than twenty, and most have but three or four.

The above diagrams have been engraved for this article by the lathe itself. They have been purposely made much more simple than those used in the bank-note business, in order that the general form may be more readily distinguished. Any one with a

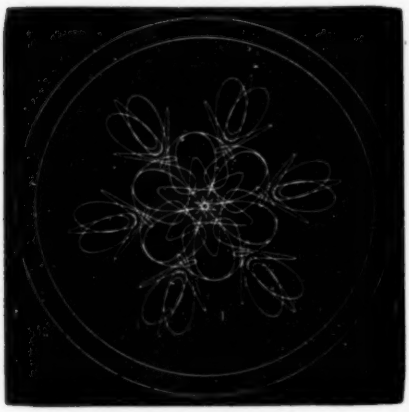


FIG. 14.—LATHE WORK.

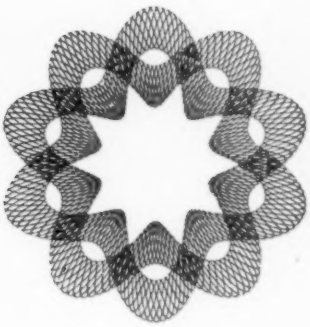


FIG. 15.—LATHE WORK.

glass and a sharp point may follow the lines which compose these figures.

One peculiarity of lathe-work should be noted. We said, in a former paragraph, that in steel-plate engraving the line cut by the graver prints black. In most of our diagrams, as well as on the notes themselves, the line is white—the interspaces being black.

The reverse would be the case if this lathe-work was printed from the plate as it is engraved by the machine. This reversal (making that sunk on the plate which is left raised by the lathe, and *vice versa*) is effected by a process that is one of the carefully guarded secrets of the trade, and therefore can not be described here. Its effect, however, is evident.

We may suppose, for instance, that a very careful engraver might possibly cut upon a plate a very fair imitation of the lines forming the figure in our last diagram, but these cut lines, remember, would print black and would give an entirely different effect; therefore the black diamonds between the white lines must be cut and the line left standing; and what hand, be it ever so skillful, could cut these black interspaces and leave the white lines in their purity and regularity? Yet this is just what the engraver must do who would reproduce on steel this figure; and, we repeat, this is far less elaborate than those in actual use on bank notes.

The tool which cuts these delicate lines is made of the finest steel; made very hard and very carefully tempered. It passes through each line of the cutting about twenty times, cutting down about one three-thousandth part of an inch each time, then continues going over the line about fifty times more to clean out the burr and polish the work. The machine must, therefore, work with perfect precision, for a deviation of one tenth part of a hair's breadth would destroy the whole cutting.

On account of this required precision, these lathes are made adjustable in every part—that any loss-motion caused by wear may be taken up. They are so sensitive as to be affected by a sudden change of temperature in the room; and if a partially finished line should be entered by the tool after such sudden change, the result would be a defective piece of work.

We may watch one of these machines for hours and each moment discover some new movement. In the hands of a skillful operator (for, after all, the machine itself, to produce the required effects, must be under the direction of human intelligence) it will produce almost any form desired.

There are only three or four first-class operators of these machines in the world, and they are all Americans. Only one of these is able to make a cutting from a pencil sketch and figure out the required combination of wheels, set the lathe, and know it is properly set and adjusted before turning a wheel. The turn of a screw, the substitution of one wheel for another—with the variation of a single cog—the shifting of the axis of an eccentric, will produce an entirely new effect; it may give distortion where perfect regularity is demanded; therefore a perfect and long familiarity with the machine is necessary to the successful handling of it.

These machines cost about five thousand dollars, and are built by the inventor, Mr. C. W. Dickinson, Sr., of Belleville, N. J., who has invented and improved several other kinds of very useful bank-note machines.

It is said the American Bank-note Company, of New York, has a lathe, built by the company some years ago, which took about three years to build and cost more than ten thousand dollars.

The variety of forms that can be produced on one of these lathes is endless; and if Spencer could have had one of these, instead of the crude one he had, and could have started with the opening of this century and cut a new form every day, Sunday included, and every hour of each day up to the present time, he would still have possibilities enough left to fill out the next century.

This machine and its work have been thus minutely described because it is considered a most important security against counterfeiting; not exceeded in value even by the artistic perfection of the vignettes, or portraits, and lettering.

Doubt as to the character of a bank note has often been settled by a microscopic examination of the lathe-work. Even by means of the lathe on which a cutting has been made, it could not be absolutely reproduced; so, of course, it could not be done by hand or by another lathe. Possibly, after reading this article, some one will look upon a bank note as something more than simply cash.

THE results of observations taken by Mr. Hallock, of the Smithsonian Institution, at depths extending to 4,462 feet, in a nearly dry well at Wheeling, W. Va., were communicated to the British Association by the Committee on Underground Temperature. When the observations taken in 1891 were concluded, the well was plugged. The plug was withdrawn in July, 1893, and the observations were resumed. The well, which had been dry before, was filled with fresh water to within forty feet of the top. The results of measurements at various depths between 1,586 feet and 3,196 feet were practically identical with those obtained two years previously, when the well was full of air, the greatest certain difference being only one fifth of a degree. The temperatures at 103 feet, 206 feet, and 300 feet were also observed with suitable thermometers, the temperature at 103 feet being 52·53°, which is 1·2° higher than the true temperature of the soil at that depth, as determined by other observations in the immediate neighborhood.

THE four-hundredth anniversary of the establishment of the earliest Slavonic printing press in the country was celebrated throughout Montenegro in July, 1893. The press was set up at Obod by the ruling prince in 1493, before either Oxford or Cambridge had a permanent press. Some of the books printed then are still to be seen at the Monastery of Cajnice, just over the Bosnian frontier. On the occasion of the celebration, universities and learned societies of Europe, including the University of Oxford, sent addresses of congratulation.

SCIENTIFIC METHOD IN BOARD SCHOOLS.*

By Prof. H. E. ARMSTRONG, F. R. S.

AT the request of my friend and former pupil, Mr. W. M. Heller, I have undertaken to say a few words by way of introduction to the course which he is about to give here to assist a number of you who are teachers in schools in the Tower Hamlets and Hackney district under the School Board for London—a course of lessons expressly intended to direct your attention to the educational value of instruction given solely with the object of inculcating *scientific* habits of mind and *scientific* ways of working; and expressly and primarily intended to assist you in giving such teaching in your schools.

Nothing could afford me greater pleasure, as I regard the introduction of such teaching into schools generally—not board schools merely, but all schools—as of the utmost importance; indeed, I may say, as of national importance; and I now confidently look forward to the time, at no distant date, when this will be everywhere acknowledged and acted on. Personally I regard the work that I have been able to do in this direction as of far greater value than any purely scientific work that I have accomplished. At the very outset of my career as a teacher I was led to see how illogical, unsatisfactory, and artificial were the prevailing methods of teaching, and became interested in their improvement. My appointment as one of the first professors at the Finsbury Technical College forced me to pay particular attention to the subject and gave me abundant opportunity of practically working out a scheme of my own. I was the more anxious to do this, as I soon became convinced that if any real progress were to be made in our system of technical education, it was essential in the first place to introduce improved methods of teaching into schools generally, so that students of technical subjects might commence their studies properly prepared; and subsequent experience has only confirmed this view. Indeed, it is beyond question, in the opinion of many, that what we at present most want in this country are proper systems of primary and secondary education—the latter especially. Now, most students at our technical colleges, in consequence of their defective school training, not only waste much of their time in learning elementary principles with which they should have been made familiar at school, and much of our time by obliging us to give elementary lessons, but, what is far worse, they have acquired bad habits and convictions which are

* From a revised address delivered at the Berners Street Board School, Commercial Road, London, on October 9, 1894, and published in Nature.

very difficult to eradicate; and their mental attitude toward their studies is usually a false one.

The first fruits of my experience were made public in 1884, at one of the Educational Conferences held at the Health Exhibition. On that occasion, and again at the British Association meeting at Aberdeen in 1885, in the course of my address as president of the Chemical Section, after somewhat sharply criticising the methods of teaching in vogue, I pointed out what I conceived to be the directions in which improvements should be effected. Others meanwhile were working in the same spirit, and consequently, in 1887, a number of us willingly consented to act as a committee "for the purpose of inquiring into and reporting upon the present methods of teaching chemistry." This committee was appointed at the meeting of the British Association in York, and consisted of Prof. W. R. Dunstan (secretary), Dr. J. H. Gladstone, Mr. A. G. Vernon Harcourt, Prof. H. McLeod, Prof. Meldola, Mr. Pattison Muir, Sir Henry E. Roscoe, Dr. W. J. Russell (chairman), Mr. W. A. Shenstone, Prof. Smithells, Mr. Stallard, and myself. A report was presented at the Bath meeting in 1888, giving an account of replies received to a letter addressed to the head masters of schools in which elementary chemistry was taught. In 1889 and 1890 reports were presented in which were included suggestions drawn up by myself for a course of elementary instruction in physical science.

Let me at once emphasize the fact that these schemes were for a course of instruction in physical science—not in chemistry alone. The objects to be accomplished by the introduction of such lessons into schools have since been more fully dwelt on in a paper which I read at the College of Preceptors early in 1891, printed in the Educational Times in May of that year. After pointing out that literary and mathematical studies are not a sufficient preparation in the great majority of cases for the work of the world, as they develop introspective habits too exclusively, I then said, in future boys and girls generally must not be confined to desk studies; they must not only learn a good deal *about* things; they must also be taught how to *do* things, and to this end must learn how others before them have done things by actually repeating—not by merely reading about—what others have done. We ask, in fact, that the use of eyes and hands in unraveling the meaning of the wondrous changes which are going on around us in the world of Nature shall be taught systematically in schools generally—that is to say, that the endeavor shall be made to inculcate the habits of observing accurately, of experimenting exactly, of observing and experimenting with a clearly defined and logical purpose, and of logical reasoning from observation and the results of experimental inquiry. Scientific habits

and method must be universally taught. We ask to be at once admitted to equal rights with the *three R's*—it is no question of an alternative subject. This can not be too clearly stated, and the battle must be fought out on this issue within the next few years.

Well, gentlemen and ladies, you have the honor of forming part of the advanced guard in the army which is fighting this battle—for the fight is begun in real earnest, although as yet on a small scale; nevertheless, in this case, the small beginning *must* have a great ending.

I had long sought for an opportunity of carrying the war into the camp of elementary education, and this came about four years ago when my friend Mr. Hugh Gordon was appointed one of the Science Demonstrators of the London School Board. During at least three years prior to his appointment, Mr. Gordon had been doing research work in the laboratory of which I have charge at the City and Guilds of London Institute Central Technical College, where he had also taken part in our elementary teaching, and he was already an ardent advocate of the educational policy of which I am so strong a supporter. Under the London School Board he achieved a marvelous success, and the work that he has done as a pioneer can not be too highly appreciated. He secured your confidence and sympathy, and interested his pupils; and working in a most unpromising field, under conditions of a most unsatisfactory and often depressing character, he has proved that to be possible, even easy (to the competent and willing teacher!), which my friends in higher grade schools have often scoffed at and declared to be impossible. In future, no public school will be able to excuse itself, except on the ground of want of will to give such teaching. I have often been told that our scheme was too costly, that much special provision must be made to carry it into effect, and that it requires so much time and such an increase in the teaching staff: my friend Gordon, with your assistance alone and no other addition to the staff, by successfully teaching, I believe, in seventeen of your schools, has given all these statements the lie. But I confess that as yet there are few who could accomplish so much; few equally well fitted and prepared for the work, so imbued with the right spirit, so convinced that the cause is a great and holy one, gifted with sufficient energy and enthusiasm to overcome the difficulties. The little book he has written, in which the first part of the course of teaching he adopted is broadly outlined,* although containing a few slight blemishes which mar its otherwise logical character—blemishes which will be very easily removed in a second edition—appears to me to be

* Cf. Nature, 1893, vol. xlix, p. 121.

a most important contribution to educational literature, and will render great service to our cause. But I count as his greatest achievement the introduction of a proper balance—calculated to inspire confidence and respect—into the schools, for I believe the discipline of learning to weigh carefully and exactly to be of the very highest value to a child, and one of the most effective means of leading children to be careful and exact in their work generally. I envy my friend his success, as I have in vain tried to get proper balances introduced into schools of far higher grade in place of wretched contrivances costing but three or four shillings, *which can be of no service in forming character*, although I have no wish to deny that such may be made use of in illustrating principles.

Mr. Gordon, I believe, was appointed to teach mechanics under what I will venture to call an antiquated and wooden syllabus, but he had the courage to burst the bonds imposed upon him, and from the outset determined to teach what was likely to be of real service to his pupils. I have said that he gained the confidence and sympathy of the teachers with whom he was associated and whose work he was appointed to supervise and direct; but I believe that he did more, and achieved success in a task of greater difficulty—that he actually made converts of some of her Majesty's inspectors whose sympathies had previously lain with literary studies.

I have thought it desirable thus to sketch the history of the introduction of our British Association scheme into school-board circles. Let me now further emphasize the importance of teaching *scientific method*, which after all is recognized by very few as yet. Let me endeavor to make clear what I mean by scientific method: that when I speak of scientific method I do not mean a branch of science, but something much broader and more generally useful. We may teach scientific method without teaching any branch of science; and there are many ways in which we may teach it with materials always close to hand.

I have very little belief in the efficacy of lecturing, and it is always difficult to persuade those who are not already persuaded —I would therefore refer those of you who are not yet with me to a book from which they may derive much information and inspiration. I mean Herbert Spencer's Essay on Education.* It is a book which every parent of intelligence desiring to educate his children properly should read; certainly every teacher should have studied it thoroughly; and no one should be allowed to become a member of a school board who on examination was found not to have mastered its contents. But as Herbert Spencer says—

* Published by D. Appleton & Co. Paper, 50 cents; cloth, $1.25.

and the times are not greatly changed since he wrote—although a great majority of the adult males throughout the kingdom are found to show some interest in the breeding, rearing, or training of animals of one kind or other, it rarely happens that one hears anything said about the rearing of children. I believe the subject is seldom mentioned in school-board debates. Hence it happens that Herbert Spencer's book has had a smaller circulation than many novels, and that the 1893 edition is but the thirty-fourth instead of the three hundred and fortieth thousand. After very fully discussing the question "What knowledge is of most worth?" he arrives at the conclusion that science is, and eloquently advocates the claims of the order of knowledge termed scientific. The following are eminently instructive passages in his essay: "While every one is ready to indorse the abstract proposition that instruction fitting youths for the business of life is of high importance, or even to consider it of supreme importance, yet scarcely any inquire what instruction will so fit them. It is true that reading, writing, and arithmetic are taught with an intelligent appreciation of their uses. But when we have said this we have said nearly all. While the great bulk of what else is acquired has no bearing on the industrial activities, an immensity of information that has a direct bearing on the industrial activities is entirely passed over. For, leaving out only some very small classes, what are all men employed in? They are employed in the production, preparation, and distribution of commodities. And on what does efficiency in the production, preparation, and distribution of commodities depend? It depends on the use of methods fitted to the respective natures of these commodities; it depends on an adequate acquaintance with their physical, chemical, and vital properties, as the case may be: that is, it depends on science. This order of knowledge, which is in great part ignored in our school courses, is the order of knowledge underlying the right performance of those processes by which civilized life is made possible. Undeniable as is this truth, there seems to be no living consciousness of it: its very familiarity makes it unregarded. . . . That which our school courses leave almost entirely out, we thus find to be that which most nearly concerns the business of life. Our industries would cease, were it not for the information which men begin to acquire, as they best may, after their education is said to be finished. And were it not for the information from age to age accumulated and spread by unofficial means, these industries would never have existed. Had there been no teaching but such as goes on in our public schools, England would now be what it was in feudal times. That increasing acquaintance with the laws of phenomena which has through successive ages enabled us to subjugate Nature to our needs, and in these days gives the common laborer com-

forts which a few centuries ago kings could not purchase, is scarcely in any degree owed to the appointed means of instructing our youth. The vital knowledge—that by which we have grown as a nation to what we are, and which now underlies our whole existence—is a knowledge that has got itself taught in nooks and corners; while the ordained agencies for teaching have been mumbling little else but dead formulas."

Some improvement there has been since Herbert Spencer wrote, but chiefly in technical teaching: and there is yet no national appreciation of what constitutes true education: fashion and vested interests still largely dominate educational policy.

Another advocate of the teaching of scientific method to whom I would refer you is Charles Kingsley, the celebrated divine, but also a born naturalist possessed of the keenest powers of observation, a novelist of the first rank, and a poet. Read his life, and you will find it full of inspiration and comfort. Study his scientific lectures and essays (Volume XIX of his Collected Works, Macmillan & Company) and you will not only learn why "science" is of use, but will have before you a valuable model of method and style. A friend—a member of the London County Council—to whom I happened to send some of my papers, noting my frequent references to Kingsley, remarked, "How very fond you are of his writings!" Indeed I am, for they seem to me to display a truer grasp of the importance of scientific method and of its essential character than do any other works with which I am acquainted. I recommend them because they are pleasant as well as profitable reading, and because our text-books generally are worthless for the purpose I have in view. Any ordinary person of intelligence can read Herbert Spencer's and Kingsley's essays and can appreciate them, especially Kingsley's insistent application of the scientific principle of always proceeding from the known to the unknown; but few can read a text-book of science—moreover, the probable effect of most of these would be to dissuade rather than persuade.

Kingsley's great point, and Herbert Spencer's also, is that what people want to learn is not so much what is, still less what has been, but how to *do*. And the object you must set before yourselves will be to turn out boys and girls who, in proportion to their natural gifts—for, as every one knows, you can not make a silken purse from a sow's ear—have become inquiring, observant, reasoning beings, ever thoughtful and exact and painstaking, and therefore trustworthy workers. To turn out such is the whole object of our scheme, which chiefly aims at the development of intelligence and the formation of character. In your schools information must be *gained*, not imparted. After describing how the intelligent mother trains her young child, Her-

bert Spencer remarks: "To *tell* a child this and to *show* it the other is not to teach it how to observe, but to make it a mere recipient of another's observations, a proceeding which weakens rather than strengthens its powers of self-instruction, which deprives it of the pleasures resulting from successful activity—which presents this all-attractive knowledge under the aspect of formal tuition. . . ." You must train the children under your care to help themselves in every possible way, and give up always feeding them with a spoon. Abolish learning lessons by rote as far as possible. Devote every moment you possibly can to practical work, and, having stated a problem, leave it to the children if possible to find a solution. Encourage inquisitiveness, but suggest methods by which they may answer their own questions by experiment or trial or by appeal to dictionaries or simple works of reference, part of the furniture of the schoolroom, and lead them to make use of the public library even; in after life you will not be at their elbows, but books will always be available, and if they once grow accustomed to treat these as friends to whom they can appeal for help, you will have done them infinite service and will undoubtedly infuse many with the desire to continue their studies after leaving school. Under our present system school books are cast aside with infinite relief at the earliest possible moment, and the desire for amusement alone remains. Teach history, geography, and much besides from the daily papers, and so prepare them to read the papers with intelligence and interest, and to prefer them to penny dreadfuls and the miserable, often indecent, illustrated rubbish with which we are nowadays so terribly afflicted. At the same time make it clear to them that the editorial "we" is but an "I," and that assertion does not constitute proof. If such be your teaching, and it have constant reference to things natural, you will also—as Herbert Spencer points out in a very remarkable passage—without fail be giving much *religious* culture, using the word in its highest acceptation, for, as he says, "it is the refusal to study the surrounding creation that is irreligious." As I have already said, one great—indeed the great—object of our teaching is the formation of character: and if you teach your pupils to be careful, exact, and observant, and they become trustworthy workers, you are giving much training of the highest excellence; and if they have enjoyed such training, what does it matter what facts they know when they leave school?

In the course that you are about to attend under Mr. Heller—the demonstrator upon whom has fallen the mantle previously worn by Mr. Gordon, and who is equally desirous of promoting and devising rational methods of teaching—you will in the first place devote your attention to exercises in measurement, includ-

ing much that is ordinarily taught under mechanics and physics, the prime object of which is to teach accuracy of observation. You will then study a series of problems, mainly chemical, which have been arranged chiefly in order to cultivate reasoning powers and to teach the research method. In fact, what we want to do is, as far as possible, to put every scholar in the position of the discoverer. The world always has and ever will advance through discovery; discoveries, however, are rarely made accidentally—indeed, we all pass from ignorance to knowledge by discovery, and by discovering how to do things that we have not done before we ever increase our powers of usefulness: we all require, therefore, to be taught how to discover, although we may never be called on to make original discoveries or have the opportunity. But as you proceed I trust that you will realize that the method which you are learning to apply is one which can be made use of in all your work—that the course has a broad educational value far transcending its special value as an introduction to physical science.

Lastly, I should like to take this opportunity of calling attention to the very great value to girls, as well as to boys, of teaching such as you are about to give. I fear that much that girls are being taught under the guise of domestic economy is of slight value educationally or otherwise, and that they are but having imparted to them little tidbits of information which they are as likely as not to misapply. Nothing is done by way of increasing their intelligence and forming their characters. Lessons which would lead them to be observant, thoughtful, and, above all, exact—lessons in method—would be of far higher and abiding value. They would then carry out their household functions with greater ease; there would be far less waste; less unhealthiness; far more comfort. I believe the need for such training to be indeed far greater in the case of girls than in that of boys. Boys are naturally apt in many ways, and, even if neglected at school, perforce develop when they go out into the world; but girls are of a different disposition, and rarely seem to spontaneously acquire the mental habits which a training in scientific method can confer, the possession of which would be of inestimable value to them. Extraordinarily little has been done as yet on their behalf, and they have been cruelly sacrificed at examinations—for which, unfortunately, they appear themselves to have an insatiable natural appetite. It is to be hoped that the new board will give the most serious attention to this matter, and that it will take steps to secure the teaching of scientific method in all the schools under its charge, whether boys' schools or girls' schools. Unhealthy buildings have attracted much attention; but the existence of a far more serious evil—the absence of healthy teaching suited to the times—has not even been noticed.

THE MOTHER AS A POWER FOR WOMAN'S ADVANCEMENT.

By Mrs. BURTON SMITH.

THERE are still thoughtful, liberal-minded men and women who persistingly declare that there should be no woman question; that women have now all the rights and opportunities which should be theirs, and that a just appreciation of what they have already would leave no time nor desire for further demands. There is a great deal of truth and justice in this position, as there is generally in any honest view of any really serious question; but the unalterable fact remains that there is a woman question, and that a discussion which has had the earnest attention and advocacy of so many high-minded, well-balanced men and women must have had its origin in the real needs of some portion of humanity. Surely, no matter what the point of view, the cause of woman's advancement on the best and broadest lines, whatever may be its highest expression to the individual, will have at least sympathy from every thoughtful human being. In this cause, with all its wide-reaching consequences, in all its breadth and fullness, motherhood has just now a peculiar call for effort.

In all great questions which set the world thinking and listening, which touch men's hearts and stir their brains, there is a necessary tendency to extremes. The very force of conviction and power of feeling which go to make the prophets and leaders, carry them away from lines of moderation. But when thought and agitation have developed into real activity, conservatism, as much as enthusiasm, is needed in any movement for reform.

Just at present the woman question is a most convincing illustration of these truths. The ardor of each side has carried its advocates to extremes, which have probably never been equaled in sociological discussion. There are women who affirm that there is no intellectual, social, or professional advancement for woman except as she asserts her independence of man, and arrays herself against him as the enemy of her sex; there are others who declare all marriage slavery, all married life under the existing state of things mere bondage. Such women are as far from the truth as the novelist who has recently attempted to illustrate in her heroine the "soul-destroying" influences of the higher education for women; or the woman who declares, "With the new school of thought, and the new class of woman it has bred, we have lost both the grace and the sweetness, both the delicacy and the virtues, of the real womanly ideal." Such rash generalizing on either side simply balances against rash generalizing on

the other; and the result, as far as their power is concerned, is a standstill, frequently followed by positive retrogression. Those whose work or sympathy might otherwise be enlisted in some branch of woman's development, simply look on such extravagances with amusement or pity, and await the next edition of feminine fantastics. A little more conservatism is needed to tip the balance in favor of sure and steady progress. There is no longer need for the agitator, when the question, in its different phases, is being discussed in legislative halls and by the fireside, by thoughtful men and women the world over; but there is great need for the conservative moderator, and in just that capacity should the mothers of the land make their power felt. They occupy a position, by its very nature, powerful beyond the possibilities of any other position on earth—powerful with God-given rights, which admit of no question and need no acknowledgment. They are burdened with responsibility, it is true, but any responsibility rightly met is a power in itself. There is no class of women who stand upon such vantage ground, who can so well exemplify all that is essentially feminine, and at the same time demand, by their rights and responsibilities, any outside aid, whether it be of higher education or suffrage, or whatever it be. There is no class of women who know so well the delights of all the dear feminine prerogatives, the power of those exquisite qualities, grace, delicacy, and sweetness, and at the same time who feel more deeply the need of any and all means of enlightenment and advancement. There are no women better fitted to temper the present discussion; none who can better offer sympathy, yet counsel moderation, to those restless sisters whose demands so often grow out of bitter personal experience and too often rise to a discordant clamor. Of course, this view has been of mothers as a class. There are, alas! pitiful exceptions—women who do not admit the responsibilities of motherhood, and women who dare not demand the rights which motherhood gives them. Such women present problems which can not be dealt with here. Certainly these remarks may apply to every mother who will exercise a certain just self-appreciation, who will devote a little time and attention to the consideration of this question, and her own duties and responsibilities in relation to it. Is it not possible for such women to show that womanliness does not mean weakness—that the very life of all lives the most womanly needs for its right living not goodness only, but wisdom, knowledge, and freedom? On the other hand, ought they not to demonstrate that in this womanliness essentially, in the clinging to it and emphasizing it, they will gain a peculiar power which nothing else can give? It is surely a strength and freedom, not to be left behind in the march onward to new strength and new freedom. It is a quality

which must be cultivated and emphasized in this "new era." It is an emotional superiority, a God-given essence, which we can not afford to lose, in our new grasp upon the intellectual forces within us. If every intelligent mother in this land could bring herself to an accurate realization of these truths—a realization of the power for broad yet conservative advancement which lies merely in her position in the plan of society—what an immediate uplifting of womankind there would be! And beyond this, too, reaching away off into the future, is the influence she exerts upon her children, and through them upon an ever-widening circle. She has great power for good in this never-ending, ever-expanding influence, which must go out to the world from her, through her children, as well as in the strong and right expression of her individuality.

Mutual understanding and sympathy, both so potent in the relation of parent and child, must be established before the woman, as mother, can, through her children, do her part in this progressive age. With that much accomplished (it is the first step, a difficult but a necessary one), let us, then, in our strength, as mothers, push on to this important expression of our work for woman's advancement—the emancipation of our daughters from the slavery of half-developed bodies and unhealthful clothing. There exists to-day a painfully small number of women who have the physical endurance necessary for the right living of any life, whether domestic or professional. All women who have felt the hampering influence of weak bodies would cry out if it would help them, "Give us strong backs and good circulation, and we can do the rest ourselves." Whatever life we contemplate for our girls, whether in college halls or kitchen—whether as lawyers, teachers, doctors, or mothers—in every work, they need physical endurance, and with us, their mothers, rest the opportunity and ability to give them great help or hindrance. It is indisputable that a good circulation and fine digestion have much to do with a normal, healthful, mental development; and no one will deny that a well-developed body, with all its possibilities of symmetry and beauty, with all its suggestions of noble appropriateness, can, and frequently does, have a material effect on the character. The buoyancy, the feeling of mastery over all problems, the exaltation mental and spiritual, which come with perfect health, are not only helps but inspirations in any work. And even if we can not attain perfection, is not an approximation worth striving for? It is a rare case where the watchful care of a mother can not do much, by prenatal as well as postnatal influence, to counteract inherited weakness, cultivate desirable qualities, and bring her child to a full fruition of its physical possibilities. This branch of the mother's work, including as it does the development of a

just appreciation of what is appropriate and healthful in dress, deserves separate and careful consideration. It is only possible here to outline those powers for the good of humanity, and of womankind especially, which have always belonged to the mother, and to emphasize the necessity for her use of them just now, when there seems to be a call which she is peculiarly fitted to answer.

Following upon a fine physical development, which is the first object to be obtained, we may expect a truer and more natural expression of tastes and tendencies, and just in that expression we must look for our guide posts and follow to some extent certainly, in the education of our daughters, the roads toward which they point. To repress all evil inclinations, whether inherited or acquired, is an accepted duty to both sons and daughters; but the careful study of capabilities, the consideration and cultivation of special talents, are privileges accorded, as a rule, only to our sons. There is no work which can not be better done with education and special cultivation than without it; and in woman's work especially, from cooking, all through the literary and professional scale, up to motherhood, the greatest and most important work of all, there is necessity for the high development—for the information, skill, discernment, and wisdom—which such advantages bring. With the possible responsibilities of the suffrage, too, either open to women as a privilege or thrust upon them as a duty —according to the individual view of the matter—the daughters of to-day have need of an education not only thorough in its details but broad in its scope. Mrs. Elaine Goodale Eastman wrote recently of a young woman who had attained "real distinction in the sciences." In writing a letter to a friend on the birth of a child, this exponent of the higher education for women uses these significant words: "Your letter brings news which never fails to thrill me. I am sure that any woman would rather hold her own child in her arms than attain to any degree of eminence in science or learning." So long as such an expression of the poet's ideal of woman can come from one who has attained "real distinction in the sciences," we need not fear the consequences of a higher intellectual development for women. The danger lies elsewhere in the derision brought upon the advancement of women by the extravagancies of some unwise enthusiasts, and in the encouragement of a spirit of antagonism between man and woman—a spirit contrary to all the laws of God, and death to the best development of mankind. This last danger was forcibly illustrated in a recent magazine article which demanded that every father should share with the mother the responsibility of the mental and physical training of his children, and entitled Modern Woman *versus* Modern Man—a most excellent subject, the very central thought of which proves the necessity for *working together*. It was well

developed too; but oh! the spirit indicated by that title. That the mother, as a member of society and the guide of future generations, can do more than any other woman to meet these dangers and counteract them, is the conviction which I believe will be born of a just valuation of her powers. In considering the growth of opportunity for women, it is natural that we should give special attention to the needs of our daughters and to the development of which they are capable. But our sons are no less important "seed fields." Even viewing woman's higher development as it affects herself individually, there is need for an influence upon the man of the future, which will awaken in him a spirit of helpful sympathy with the earnest woman who is trying to dignify and broaden her life and work. And considering this increasing earnestness in woman in its wide-reaching effect upon all mankind, it is evident that, without a kindly fellowship and encouragement from men, which will make the working together possible, the future will not bring the great results which are hoped for. Would it not be well to infuse some of this spirit into our sons while their natures are still plastic material?

In writing recently of woman's work, Miss Agnes Repplier said with admirable force, "Now as in the past character is the base upon which all true advancement rests secure," a truth which must commend itself especially to every conscientious mother. It is through a better physical and mental development, it is true, but mainly through them as leading up to a growth in character, that we must look for the best results. If there is to be a "new woman," let us have her by evolution, not revolution.

Let us free our daughters from the unwholesome physical restraints which unnecessary conventionalities would impose, and educate them as *human beings*, with all ordinary possibilities latent, besides those womanly qualities which set them apart. Let us cultivate in them all that is strongest and most forceful, all that is sweetest and best and most womanly; and then, with the realization that neither marriage nor a career is the essential, "the destined end," there will come to them a growth in strength and goodness which will enable them to do any work in life better than they have done it in the past. It is certainly not incredible that such women should be able to counteract every retarding influence, and hand in hand with broad-minded men as husbands, brothers, or co-workers, demonstrate the beauty and strength of united force.

Is it too much to hope that in the near future there will arise in the minds and hearts of mothers a whole army of thoughts and inspirations with which they may do battle for that high development, that noble expansion, which we are pleased to call "the advancement of woman"?

WELLNER'S SAIL-WHEEL FLYING MACHINE.

By Miss HELENE BONFORT.

ONE of the latest and most ingenious schemes for solving the problem of aërial navigation is that devised by Prof. G. Wellner, of Brunn, Moravia, who has sought to bring in the application of a new principle. He calls his apparatus the "sail-wheel flying machine" (*Segelrad-Flugmaschine*), and regards the mechanism of it as a kind of cross between those of the screw-propeller and of the kite, combining the advantages and avoiding the inconveniences of both. His system has won approval and confidence from eminent engineers and experts in aërial navigation to such an extent that the Vienna Association of Engineers and Architects is having experiments and observations made which will show very soon the degree of practicability and value possessed by his invention.

In his paper on the subject, Prof. Wellner describes his line of thought and the result of his researches, prefacing them with a summary of the experiments and investigations of his co-workers.

The oblong form of balloons chosen by Giffard in Paris in 1852, by Dupuy de Lôme in Vincennes in 1872, by Tissandier in 1883, and by Renard and Krebs at Chalais in 1885 for their balloon "La France," conquered to a considerable degree the resistance of the air and thus increased the velocity (Fig. 1). They contained electro-dynamic motors with a galvanic column so admirably suited to the apparatus as to secure the greatest possible power with the least weight. Various improvements made obviated the danger of pitching. The "La France" almost completely fulfilled the condition that the balloon must return to its point of departure; in seven ascents a return was five times made to the starting point, showing that five times a complete control of direction had been gained. A speed of 6·5 metres per second (about fourteen miles per hour) was reached. Efforts have been made by the French military department to double this velocity, making it thirteen metres per second. This would be important, as in aërial navigation direction can be controlled only by velocity. But the weight of the motor required for such great power must constitute a serious embarrassment. Moreover, the pressure of air currents and the resistance of the wind endanger the balloon constructed of light material.

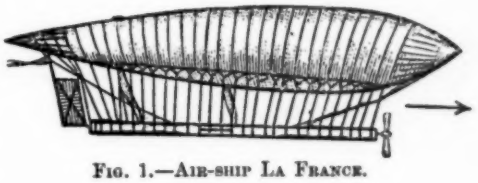


Fig. 1.—Air-ship La France.

These circumstances lead to the conviction that the aëronautic problem will most probably admit of a satisfactory solution only by means of dynamic flying machines. Prof. Wellner is of the opinion that, manifold as are the difficulties besetting the road to this end, it is likely to be attained before the close of our century. The inventor's starting point is the observation and analysis of the flight of insects and birds, which have of late been made possible by the graphic methods of chronometric observation and photography. It would, of course, be a mistake to attempt a close imitation of the organs of motion observed in birds or insects, as these would lose their utility through the unavoidable clumsiness of man's appliances. What must be aimed at is the most advantageous shape and construction of wings, productive of the greatest propelling power with the expenditure of the smallest possible sum of energy; the application of a light but powerful motor; a contrivance for easy and efficient steering, available alike at the time of the ascent, while flying, and in alighting; and arrangements for the prevention of accidents.

It may be regarded as an established fact that gently curved or arched surfaces, pointed toward their ends, make the fittest wings for flying machines; they must be carried against the atmosphere at small angles. The lifting power of the wings arises from the carrying quality of the air compressed and forming, we might say, an air-cushion under the aëroplanes. The air pressure increases in a duplicate ratio to the velocity of the latter; consequently very small wings are capable of great lifting power when vigorously and swiftly plied. In order to advance the air-ship, a power imparting horizontal motion is needed; this has to be secured by a retrograde movement, thrusting the air backward and thus causing it to propel the air-ship. The shape, position, and direction of the aëroplanes will have to be such as to combine the vertical lifting with the horizontal propulsion. The two great distinct groups of air-ships attempting to secure this end are those propelled by screws and those working on the principle of a kite.

The models constructed by Ponton d'Amécourt, Achenbach, Dieuaide, Forlanini, Philipps Popper, Jarolimik, and some others are based on the screw principle. They employ propeller screws moving horizontally on vertical axes and connected with aëroplane surfaces which are capable of inclination between the horizontal and vertical positions like those of a windmill. These aëroplanes pressing down the air act very much like the propeller screw in a ship, which drives the water backward so as to make it move the ship forward. The difficulty inherent to this construction arises from a considerable loss of motive power, caused by the difference in revolving speed of the screw at various points

nearer to or remoter from the axis. This difference of speed in the turning of the screw combined with the inevitably small angles at which its slanting surfaces are presented to the wind make it incapable of developing, by the help of any of the dynamo machines now in use, a power adequate to the weight of the machine itself, its accessories, and the aëronauts.

The laws that come into play in the flying of a kite are involved in the flight of birds independent of the movement of their wings. In calm weather the kite is moved forward by the boy, who runs along, drawing the string with him. This movement, creating a wind under the kite, causes the air to gather under its slanting surface, and thus calls into play the lifting power of the atmosphere. The flying machines propelled from the rear by a motor with sufficient velocity, on rising into the air are enabled to soar on the same principle. The stronger the wind, the better the kite will rise; the quicker the horizontal motion of the flying machine, the better its aëroplanes will develop the supporting

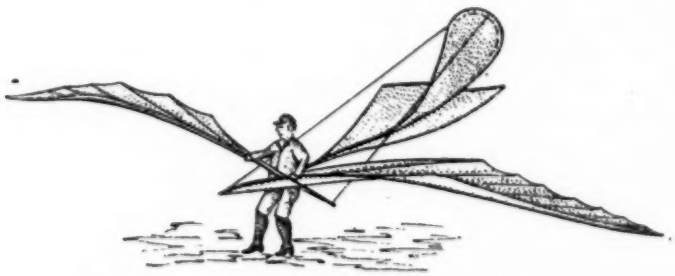


FIG. 2.—LILIENTHAL'S FLYING APPARATUS. The start.

power of the air. The exertion made by a bird on traveling a long distance is smaller, and its sailing power greater, the faster it flies.

The fastest fliers have the smallest wing surface. Some birds even reduce the area of their supporting surfaces when they increase their speed by drawing in their wings and closing their tails. Consequently, in order to keep the aëroplanes of the flying machine within a moderate size, considerable velocity has to be developed. This at the same time serves to overcome the resistance of the wind and of air currents. The air-ship is not capable of maintaining the direction pursued unless its velocity is so much greater than that of the strongest wind that it can overcome the latter and yet have velocity to spare.

While the construction of the kite machines seems to insure success through the high velocity of movement that must be attained, a new obstacle arises from the difficulty of ascent. The speed of motion being the condition of their rising power, they

can not be made to ascend slowly. Once progressing on their road with the tremendous speed adequate to their weight and wing surface, the kite machines can not be stopped or propelled at a lesser rate without at once descending from the level attained.

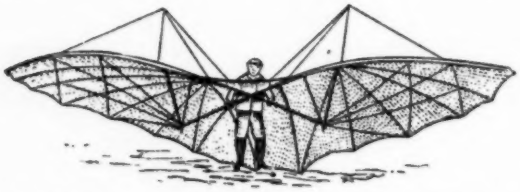


FIG. 3.—LILIENTHAL'S FLYING APPARATUS. The landing.

The contrivances applied to counteract these disadvantages have not proved efficient to overcome them. Nevertheless, the experiments and constructions made by Stringfellow, Moy, Tatin, by Kress in Vienna, Lilienthal in Berlin, Koch in Munich, Philipps, Langley, Edison in America, Maxim in England, and by Hargrave in Australia, all represent so many stages of constant progress. Mr. O. Lilienthal has just succeeded in floating down at a moderate rate from a height of two hundred metres; his personal skill in the handling of the apparatus adds considerably to the advantages derived from its judicious construction (Figs. 2, 3, and 4). Some of the most remarkable experiments in the field of aërodynamics are those devised and carried out by Prof. Langley.

The essence of Prof. Wellner's innovation is his invention of the sail-wheel (Fig. 5). It consists of a horizontally placed axis with spokes and arched aëroplanes attached to them in a cylindrical form. While revolving round the axis the latter take a slightly slanting position, which causes the forward edges of these surfaces to be inclined, and consequently to compress the air in the way of a sail or a kite, calling into play the vertical force. Three ribs running across each lifting surface and made in the form of a screw at the same time serve to strengthen the aëroplanes and to add to the horizontal force.

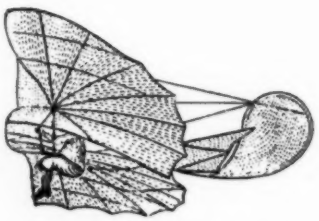


FIG. 4.—LILIENTHAL'S FLYING APPARATUS. In flight.

These sail-wheels set in pairs can be placed, according to the size of airship aimed at, in one or more groups of two wheels, revolving in opposite directions, behind or beside each other. The cigar-shaped car, furnished with a motor and carrying the aëronauts, is attached horizontally under the center of the wheels, so that the whole construction will resemble a colossal bird, propelled, instead of by wings, by revolving wheels, the lifting surfaces of which are consecutively and constantly developing vertical and horizontal power. The bird's movements in flying and the speedy headway motion necessary to the kite-

flying machines for their support in the air are in Prof. Wellner's invention changed to a rotary motion. This construction, while permitting of an easy, slow ascent, assures the horizontal position and constant stability of the air-ship, at the same time permitting of a high velocity. The more the latter is increased, the stronger is the lifting power developed. The direction is given by a rudder at the end of the ship or by increasing the velocity of the sail-wheels on one side only. It is the peculiar quality of these wheels that they do not, as might be supposed, disperse the air around them; they rather attract it toward their rapidly moving surfaces, condensing it to a powerful stream, which passes down obliquely through their cylinders. Their velocity can be made to surpass by far that of railway trains, thus enabling them to conquer contrary winds and air currents. This flying machine

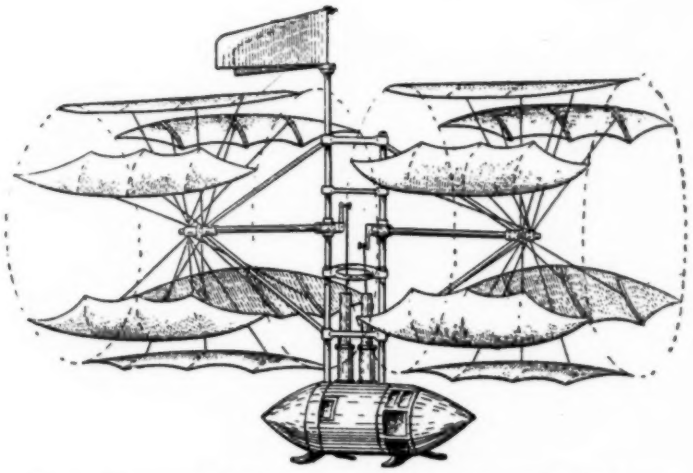


FIG. 5.—WELLNER'S SAIL-WHEEL FLYING MACHINE FOR TWO PERSONS.

will hardly be called upon to rise above the cloud region; it will be most efficient to reach its goal on the shortest air line at a moderate height above the earth.

Fig. 5 shows a small sail-wheel air-ship for two aëronauts. Each of the two wheels has a diameter of 4·77 metres and six planes five metres wide. Two steam engines of twenty horse power each are said to produce during one hundred and eighty rotations per minute a velocity of forty-five metres, a soaring speed of fifteen metres per second, and a carrying power of fifteen hundred kilogrammes.

A larger machine (Fig. 6), comprising six sail-wheels of 6·4 metres diameter and a steam motor representing eighty horse power, will, at one hundred and thirty-five rotations, carry sixty-four hundred kilogrammes and accommodate eight persons.

The latest experiments with Prof. Wellner's flying machine do not seem to favor the construction of those air-ships which are intended to rise by the strength of their lifting power only, this power sufficiently outbalancing their weight. Some eminent European aëronauts—Profs. Pistio, Miller, Hauenfels, and Wellner himself—now favor the principle of partial disburdening by the application of some gas or other, which will add to the lifting power of the machine.

Important and very animated discussions of the present aspect of aëronautics have recently taken place in London and in Vienna. In the Aëronautic Section of the British Association Prof. H. Maxim laid before his colleagues a detailed report of the

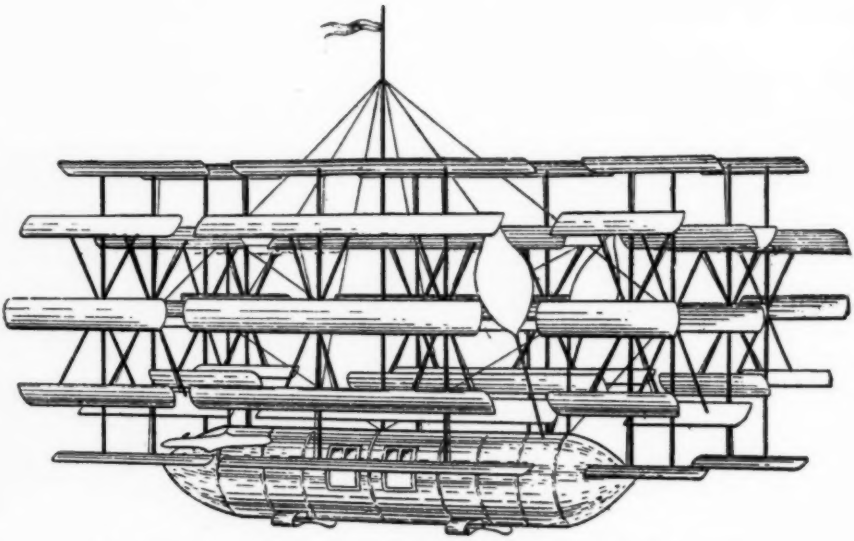


FIG. 6.—WELLNER'S SAIL-WHEEL FLYING MACHINE FOR FOUR PERSONS.

experiments made with the model which he has had constructed for the purpose, and which, though it has met with an accident and has not led to a definite result so far, has certainly brought the vital question nearer to its solution. Prof. Maxim's apparatus is a wonder of ingenuity. It carries its provision of fuel in the form of naphtha in a small, exceedingly light boiler, so constructed as to cause a constant, unvarying pressure. The machine proved able to rise and fly for thirteen hours at a velocity of more than fifty English miles per hour. Its two large screw-propellers are set in motion by two compound engines, the strongest in proportion to their size that have ever been made. Their construction allows of the power being raised within one minute from two hundred to three hundred and twenty-five pounds per square inch. The screws are capable of more than five hundred

rotations per minute. The entire weight of this flying machine and crew is eight thousand pounds and its lifting power ten thousand. Unfortunately, the surplus power of two thousand pounds during the experiment lifted the machine off the rails on which it was running, and broke the rear axletrees that were holding it down, thus wrecking the apparatus. The prominent English physicists, Lord Kelvin, Lord Rayleigh, etc., speak of Maxim's air-ship with the greatest enthusiasm; they expect him actually to solve the problem in a near future. The German scientists, however, at the Sixty-sixth Congress of German Naturalists, which was held in Vienna in September, stated that while Maxim's experiment has certainly brought the problem nearer its solution, it has cost one hundred and fifty thousand dollars, and left the question of steering the air-ship, which is at present the greatest impediment to ultimate success, altogether unimproved. They expressed their hope of seeing the real invention made by a German, after all, although their nation does not command pecuniary means which permit of such costly experimenting as that done by Mr. Maxim, whose apparatus, they say, is in its main traits merely the application of Mr. Kress the German inventor's model, executed in colossal dimensions. Mr. Kress demonstrated before the assembly the capacities of his model, which he constructed some years ago, and was loudly applauded as his machine rose with great speed and landed at the appointed place on one of the galleries. Prof. Ludwig Boltzmann, of the Vienna University, gave a general survey of the latest inventions. He considered as a very important step the work done by the engineer, Mr. Otto Lilienthal, in Berlin. This gentleman, while using a flying machine of the smallest possible dimensions, has made great progress in the art of steering it, partly by the application of a rudder that takes the place of a bird's tail, partly by well-calculated motion of his own body and feet. An extensive practice is likely to produce absolute mastery of this part of the problem. "The aëronaut," said Prof. Maxim in his report before the British Association, "has to excel not as an expert in technique only, but also as an acrobat." This implies the same conception of the task to which Prof. Boltzmann gave utterance when speaking of Mr. Lilienthal's work and its prospects. He added that Mr. Kress has recently constructed an apparatus for steering which is based on new principles and gives fair promise of good results.

MONTENEGRO enjoys a paternal government. Mr. W. H. Cozens-Hardy tells of an officer who, when asked why he had put five men in prison, replied that they had seen after dark a figure dressed in white, sitting on a grave. Ghost stories, he said, were bad for public morals.

BIOLOGICAL WORK IN SECONDARY SCHOOLS.

By ALFRED JAMES McCLATCHIE, A. B.
DEPARTMENT OF BIOLOGY, THROOP POLYTECHNIC, PASADENA.

I SHALL not attempt to go over all the ground covered by the above topic, but shall simple lay special stress upon a few points. I shall put in a plea for genuine, systematic laboratory work upon plants and animals; shall insist that, in studying both, students become familiar with the general structure, physiology, and classification of members of all the main groups from the lowest to the highest; shall urge the necessity of teachers especially trained for the work; and I shall then attempt to point out the training that should result from such a course of study.

It should not be necessary to spend much time in urging the importance of laboratory work in the study of biological subjects. It seems strange that any teacher should ever think of having a pupil spend the precious hours of his school life in studying plants and animals in any other way. But the fact that only a small per cent of our teachers are pursuing the laboratory method makes it imperative that somebody plead in behalf of the students of our public schools. By laboratory work I mean the dissection of plants and animals for the purpose of discovering the facts concerning them, not the verifying of statements made by text-book or teacher. It is a very common mistake on the part of teachers to think they are doing the best they can for their pupils when they themselves bring in or require the pupils to obtain specimens that will illustrate their own or text-book statements. Students should be original investigators, and should be deprived of none of the pleasures connected with original investigation. Only laboratory guides and reference books should be put into their hands. The teacher and laboratory manual should aid pupils in the discovery of truth, but should never rob them of the pleasure of discovering it for themselves when practicable. As F. Mühlberg says:* "Of course, one gets on faster with a child by carrying it, but it is for the child's interest to teach it to run and swim for itself. In the same way it is better not to give young scholars scientific knowledge ready made, but to teach them the way to it. By imparting to them results obtained by others the ideal purpose of instruction is seriously prejudiced, the sense of scientifically accurate thinking is destroyed, the belief in authority is increased instead of checked, and the mind becomes surfeited, instead of finding

* Natural Science in Secondary Schools. Bureau of Education, Washington, D. C., 1882, p. 3.

pleasure in the exercise of its powers." Laboratory work upon any given object should always precede, never follow, the class discussion of it. If it is impossible for the teacher to supervise laboratory work previous to each recitation, then at least three recitation periods of each week should be thus spent, with drawing as a regular part of the work.

In the study of neither plants nor animals should the work be confined to the highest groups. After trying various methods, I am fully satisfied that the plan in general should be to study the simpler forms of life first, and proceed from these to more complex ones, until the highest forms are reached. I find that even young pupils enjoy following Nature's order in the study of living things. To do this to good advantage it is necessary to have the use of at least one good compound microscope; but I take it that most teachers of science are now agreed that to attempt to do biological work without this instrument is not using time to the best advantage. If it is impossible to equip the school for doing biological work in the right way, it is far better that pupils should spend their time upon something from which they can get good discipline. But a properly trained science teacher will not let a school be long in such a condition.

As botany is more generally studied in our secondary schools than zoölogy, and as the method of presenting it is ordinarily so poor, I shall speak of plant study the more fully. It is well known what the usual method is. It is about the same as that which was in vogue when even the oldest of us studied what was called botany. We began in the spring, and learned the names of the different shapes of leaves, stems, roots, and flower parts, with as much seriousness as if this knowledge were really important; then we "analyzed" (as it was called) a few plants, probably pressed and mounted them, heaving a sigh of relief as the name of each was determined and the plant properly ticketed. There was little discipline in such work. The principal aim was to be able to find the scientific names of a few plants. The result to most of those who pursued such a method was a bundle of dried plants and a bundle of still drier facts. To be sure, the statements of the book are often verified or illustrated by specimens brought in by teacher or pupils; but it seems to occur to few instructors that the process ought to be reversed, and the pupils be directed in making a careful study of a plant, in drawing and describing its organs, and then be given the names for these organs.

The study of plants should extend through the year. There is little to prevent this in any State. Prof. Bessey, of the Nebraska State University, says:* "Remember that plants are

* Elementary Botanical Exercises. Lincoln, Neb., 1892, p. 3.

with us all the year. The prevalent custom of assigning the spring term only to botany is a relic of scientific ignorance which should long since have been discarded. All Nature studies should extend through the year." President, Coulter, of Lake Forest University, writes:* "How many who teach botany are laboring under the impression that botany can be taught only while flowers are blooming? Plants are always with us, and are always fit subjects for study; and is not a moss, or a toadstool, or a seaweed as truly a plant as a buttercup? The only difference is that a buttercup is far more difficult to understand than the others, and is not so fit a subject for elementary study. It is ignorance that makes the toadstool seem difficult and the buttercup easy. From my own experience, and from the testimony of others, I know that children make no such distinctions and find no such difficulties, and in this way they follow Nature."

Unless pupils study the lower plants they get no conception of the great scope of the vegetable kingdom and of the development of one group from another. Fortunately, most colleges and universities are abandoning the old, irrational method, and are adopting the more rational one of giving instruction in the lower plants, instead of spending so much time in learning, for example, the different forms of leaves that seem to be able to perform their functions just as well whether they are "elliptico-oblanceolate" or "palmately-plurifoliate." They have been giving instruction in bacteria, the group of plants that is probably of more importance to man than all the rest combined; they have been having their pupils study the rusts, smuts, and mildews that destroy crops, as well as the more beautiful forms that frequent water and are considered offensive by those unacquainted with them. But the secondary schools, not having properly trained teachers, and not being properly equipped with instruments, have in most cases followed the old method. In fact, most teachers of botany suppose the lower forms too difficult for beginners in secondary schools; but in a few the experiment of beginning with these forms has been tried and the practicability of it verified.

Further, unless pupils learn something of the lower forms of plants they always have an erroneous idea of what a plant really is, and how it differs from an animal. I have found, by testing pupils that have studied in the old way, that they always define a plant as something stationary, as composed of roots, stems, and leaves, and as reproducing by seeds—all of which applies to the higher plants only. In short, they have no real knowledge of the science of botany. It is impossible to understand the structure and the reproductive system of the flowering plants unless the

* School Review, March, 1893, p. 143.

lower ones have been previously studied. On this point B. Fink, writing in Science, says:* "I wish to enter a protest against the method of teaching botany still in vogue in certain colleges and high schools; . . . the old plan of a spring term in botany confined to a study of phanerogams, followed by the analysis of from fifty to one hundred plants. This way of studying botany came into use when the microscope was scarcely known among the masses, and when the economic interest of the lower orders of vegetable life was not well understood. . . . Instead of the old plan, I would have all schools during the first term take up the orders, proceeding from the lowest to the highest, and close the work with the leading facts of vegetable physiology. I would divide the time equally between cryptogams, phanerogams, and physiology. This both gives the best foundation on which to build, and is the most essential knowledge for the student who can not give more time to the subject." President Coulter gives as his opinion the following:† "It is more satisfactory and scientific to begin with the study of the simplest forms, not merely because they are far easier to understand, but also because this order of study will give some notion of the evolution of the plant kingdom. The many advantages of this order of study—advantages which have been seen in much experience—should outweigh any supposed advantage in beginning with the study of the most complex plants. In my own experience both methods have been tried, and in beginning with flowering plants and then afterward approaching them from the lower forms, I have invariably found that previous wrong conceptions of the higher forms had to be corrected. I thoroughly believe that no proper notion of higher groups can be obtained without previous study of the lower ones." Prof. Campbell, of Stanford University, advocates strongly following Nature's order in plant study, of which fact his excellent text-book is the best evidence. In response to inquiry on this point, he writes: "I have never had any serious trouble, even with quite young students, in beginning with the protophytes. One advantage in beginning with microscopic work is that it requires an amount of concentration upon a single object that is very valuable in forcing the student to observe accurately, especially when he is obliged to draw carefully what he has seen."

Plant physiology ought to receive more attention than it now does. To study the structure of an organ without considering its use is of little value. In fact, the chief object of morphological work should be to furnish a basis for physiological and systematic work. Enough time should be spent upon classification to

* Science, October 20, 1893, p. 217. † School Review, March, 1893, p. 148.

enable students to become familiar with the limits and characteristics of the main vegetable groups. To know how to determine the scientific name of a plant is also useful, but is of secondary importance.

It may be objected that the teachers now in our secondary schools are not sufficiently trained to carry on this work properly. Better give no instruction in it at all, then. But this need not be the condition. If all our boards of education fully realized the need of special training in this line, and were not, in many cases, so lamentably corrupt; and if vacancies were always filled by the deserving, instead of those who have a "pull," we would have plenty of teachers in our secondary schools in sympathy with and abundantly prepared for this work. Our universities and other higher institutions are sending out plenty of well-trained science teachers, who stand ready to supply any demand for their services. As to the training that science teachers should have, F. Mühlberg * expresses the opinion that "the teacher of natural science ought to have the necessary special scientific schooling for that purpose. In no department of instruction is it less permissible to teach authoritatively than in this, and to make it a subordinate branch for a teacher not specially prepared for it is often worse than to provide no scientific instruction whatever; the teacher must not only be master of the material he teaches, but ought also to be a model of the intellectual training he tries to impart; he should have the capacity to observe, describe, and reason accurately about the material of study. In order to give his instruction in such a way as to incite his pupils to an interested activity in their studies, it is indispensable for him constantly to try to develop his own intellectual powers further, and continually refresh them by special studies."

But the most important point is yet to be considered, viz., the development that ought to result from pursuing such a course of study.

The first thing that all beginners must learn is to see a thing just as it is. None of us have this power fully developed. We go through life with our eyes only partially open. We do not see things as they really are. The first power that a proper study of plants and animals develops is that of observing accurately. None do this when they begin the work. Usually they see at first only vague generalities. But the best stimulus to seeing accurately comes through expressing what has been seen. This expression should be required of the pupils in three forms: drawing, notes, and oral discussions. This is a very valuable part of

* Natural Science in Secondary Schools. Bureau of Education, Washington, D. C., 1882, p. 6.

the exercise. To be able to express accurately with a pencil point what is observed is a power of inestimable value. However, the power to observe accurately is not necessarily accompanied by the power to express accurately, but the former must precede the latter. No one can draw accurately what he has not seen accurately. And along with this mental development must also go a moral development. Seeing accurately is only seeing the thing as it actually is—that is, seeing the truth; and drawing and describing are only stating the facts, or telling the truth. Here is where the temptations lie. An indolent or careless pupil finds telling the exact truth with his pencil point to be arduous, and is tempted to distort or only partially represent the truth. But accuracy of expression must be a constant drill in truthfulness.

But, along with the seeing and expressing, pupils must be led to think, if the work is to be of much value. What is the relation between this observed fact and that observed fact? What must be the use of this organ? Why is it so constructed? Why why? why? These are questions that should be continually brought before them. This is the shore upon which many are at first stranded. They may see fairly well, they may draw and describe fairly well; but to answer such "whys" is something to which they are not accustomed. However, they launch out little by little, and eventually become bold explorers on the ocean of truth. But besides being able to answer "whys," they should learn to deduce laws from observed facts, and to make predictions as to future processes. Here the power of imagination, that is so important in all school work, must be exercised. Without this power few "whys" can be answered, few deductions made, and no processes predicted. If a pupil can build up in his mind a plant or animal, with or without this or that organ or set of organs, and can then imagine what functions could or could not be performed by his creation, he has a power that will aid him in any work to which the duties of life may call him.

But as yet I have said little concerning the value of the facts learned in pursuing such a course of study. The value of the information gained was formerly the chief reason for studying natural history, as it was called. But now the best educators know that the power to discover truth, to acquire knowledge, is of far greater value than simple possession of knowledge. However, the information obtained from the study is of great value to any one. For example, in studying progressively the structure and use of the organs of the animals below man, they get accurate ideas concerning their own bodies. I make a special effort to have them get correct ideas concerning sexual organs and processes, that subject concerning which there is such a wide spread ignorance and such a lamentable amount of false modesty and

reticence on the part of both those who should receive and those who should impart this instruction. The study of the sexual processes in the lower plants furnishes an excellent opportunity to get correct ideas concerning sex. The sum total of the information gained can be greatly increased by the reading that pupils should do after making a thorough study of the object. They can appreciate and remember the illustrations and opinions of others after they have made drawings, written descriptions, and expressed opinions of their own. This is a part of the work that is too frequently omitted. Biological work is often merely a study of types, without sufficient reading to get the connecting facts.

What this work ought to do for its students, then, is to train their powers of observation; to teach them how to discover truth for themselves; to train them in expressing discovered truths in the form of drawings and in written and oral language; to train them in the power of getting thoughts from the writings of other investigators; to lead them to see the beauties and harmonies in Nature, and incidentally to give them information concerning life and life problems that will be ever useful to them in any occupation they may choose.

THE "MUTUAL AID SOCIETY" OF THE SENSES.

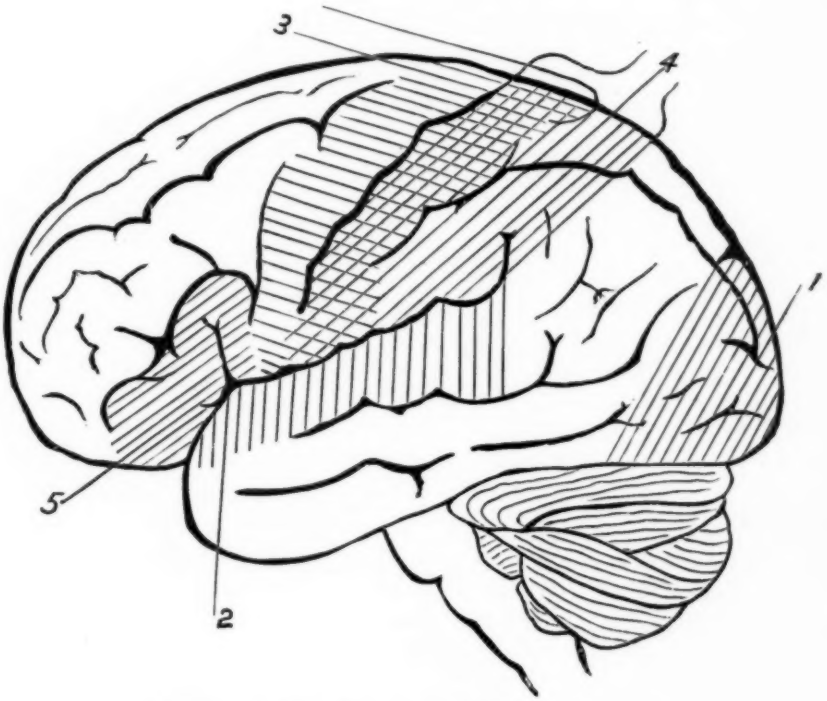
By Dr. S. MILLINGTON MILLER.

NUMEROUS images have been felicitously employed to illustrate the significance of the human brain. Drummond, in his book on The Ascent of Man, likens it to a great table-land, traversed by many broad highways, studded with mighty cities, broken up into an endless maze of cross-roads and paths, with some mere faint trails. The cities are the originating centers of gray matter; the highways the constantly traversed paths of ordinary thought; the cross-roads and bypaths its correlations; and the trails, the solitary, unfrequented channels of new and original ideas.

A better simile, perhaps, would be to typify the human brain by some rich mine, with numberless operating centers, connected by subterranean, well-worn passages and alleyways. The number and complexity of these is constantly increasing, as new lodes of ore are opened up, and still newer short cuts are daily blasted out for the economical conveniences of transportation and discovery.

"Suppose I want to buy a dynamo, as power for an electric light, or for the movement of machinery," said Dr. Walter E. Fernald (I am clothing his idea with my words), the Superintendent of the Massachusetts State Asylum for Feeble-minded Chil-

dren, at Waverly, Mass. "Here is one which is cheap, but limited in its possibilities. It can only feed so many lights, or will only give me so much horse power. Here is one larger, perhaps, but not noticeably so, which is warranted to support ten times the circuit, and to develop ten times the gauge of physical motive energy. I examine them closely, and I find the difference of the two to consist in the complexity of their coils of wire. The lesser power dynamo, with fewer volts, has coarser coils and fewer of them; whereas the more powerful developer of energy consists



OUTLINE OF HUMAN BRAIN, SIDE VIEW. (After Ecker.)

1. Area of sight and its memories.
2. Area of hearing and its memories.
3. Area of motion and its memories, { upper one third, leg. middle one third, arm.
4. Area of touch and its memories, { lower one third, face.
5. Area of motor speech-memories.

The areas of motion and general sensation coincide to some extent.

of endless and delicate windings and layers of wire." The difference between the normal and idiotic brain is entirely one of complexity.

The central nervous system consists practically of ingoing fibers from the various organs of sense, and of nerve cells for receiving and retaining impressions conveyed by these fibers. By some as yet unexplained power of co-ordination these cells com-

bine these impressions and evolve new combinations of them, which are rendered manifest externally by impulses sent through a set of outgoing fibers to the various organs of motion.

A diagram is here reproduced showing the localized areas of sight, hearing, touch, etc., in the human brain, and their relation to the motor centers. It should be stated, in passing, that these centers are in duplicate, or pairs—one of each on each side of the brain.

The purpose of this article is to show by numerous facts that, when one of the senses is lost by accident, or when it is congenitally absent, the other senses, in persons otherwise normally constituted, become preternaturally keen, and this in a way to compensate in some degree for the loss of power in the disabled or absent sense. It is this that I have ventured to call the "Mutual Aid Society of the Senses."

The historian William H. Prescott, of Boston, who was himself blind, used to say that "the blind man saw little outside of the circle drawn by his extended arms, but that within that circle he saw more than those whose eyes were sound."

In considering my subject I will first narrate a very curious illustration of the strangely wayward, atavistic recurrence of blindness, deafness, and idiocy in collateral branches of an originally tainted stock.

I am indebted to Dr. A. Graham Bell for a very interesting story about a little hamlet in a certain isolated portion of New England. He happened accidentally at one time to come across a gentleman resident in that section who had an immense mass of genealogical statistics (made out on little slips of paper which he kept stuffed in different small bags) covering the family trees not only of his own neighbors, but also of descendants of the old stock now scattered all over New England.

From this unique material, which Dr. Bell has helped to put in usable shape, he became acquainted with the fact that this hamlet was a very peculiar little town, and had been so for twelve generations—ever since its original settlement. Its peculiarity consisted in the fact that one out of every twenty-five of its inhabitants was deaf. Two of the family who were its original settlers had been deaf; and this original leaven of affliction, like the veritable yeast plant itself, had gone on budding and sprouting and ramifying, until at the present day the whole town has a flavor of affliction; and, strange as it may seem, it is not only deafness (and dumbness) from which its quaint inhabitants suffer: some of them are blind, and some are idiotic. Dr. Bell has so many data in his possession that he has not had time as yet to thoroughly digest them all, but they strike him somewhat in this wise. All the way down and through one branch of an originally

tainted stock deafness occurs, and disappears and recurs, generation after generation; and in another *collateral* branch blindness pursues the same wayward and yet persistent course; and strangest of all, idiocy itself creeps out here and there. Blindness and deafness are not the children of idiocy, but blindness goes on intensifying its peculiar brain cell and fiber lesion until the whole central shrine of the mind is vitiated and an idiot is born; and deafness grows and grows into a similar vice of the whole nervous system.

All this means that blindness and deafness are ill weeds which thrive apace if left uneradicated by proper specific education, and that, like the fly in the potter's ointment, they in time impeach the entire mental integrity.

The percentage in this town is, therefore, greater than anywhere else as regards its ratio of afflicted persons. They are like Darwin's cats with white fur and blue eyes, who are always deaf.

Miss Camilla E. Teisen, who was formerly employed in Johan Keller's Institution for Feeble-minded Children in Copenhagen, Denmark, and who is now settled down as chief instructress in the Pennsylvania Institute for Feeble-minded Children at Elwyn, Pa., has very kindly answered a number of pertinent questions which I asked her regarding the relative physical condition of the senses in idiots.

Miss Teisen regards the sight and hearing of feeble-minded children as the senses most frequently defective. She thinks sight the most important sense to develop, and that most easily developed. She feels assured of development in other directions as soon as the idea of color dawns upon the child's mind. According to her experience, the development of one sense is accompanied by improvement of the other senses. And yet exceptional cases have presented themselves to her notice where the development of one sense has seemed to leave the other stationary. Miss Teisen has found it impossible to reach the moral sense without a fair development of the physical senses. Improvement of the physical senses has been usually shown to improve the habits and manners. A child that distinguishes sound and appreciates music will not be so likely to howl and scream, and a child that feels the influence of color is far less inclined to tear its clothes.

Miss Teisen makes one statement of unusual interest. She says that many of the children of lowest grade have perfect sight, which their minds can not use. This very striking announcement opens the way to the question as to whether the structure of the image-field of sight, together with both that of afferent and efferent nervous fibers (the carriers to and from the brain) may not in many cases be approximately perfect, and the great and

perhaps only desideratum exist in the original centers of apprehension and action—the gray tissue cells of the brain itself.

As a commentary upon Miss Teisen's views, I may add the very interesting statement of Dr. Fernald, that the reason why sound and color give so much pleasure to the feeble-minded is that the simplicity of their brain and nerve fiber requires a greater blow of sense, so to speak, to affect it pleasurably. The idiotic child has the peculiarity (shared with it by Alexander III and the composer Bach) that he is most affected by loud music. In the same way fullness and force of color give the greatest pleasure to his eyes, such as the gorgeous crimson rose, or the serried stalks of full-petaled sunflowers, or huge beds of brilliant feathery chrysanthemums.

Instructors of the blind have always regarded the sense of touch as increased by the loss of sight. The fuller opportunities for close aural attention and thought—concentration, due also to their blindness—have been noted. There is no question but that the blind derive unusual enjoyment from music, and that their chief pleasure is found in listening to it.

There is an absolutely infinite field open for the improvement of the blind in clay modeling, which is already a main feature of their education. But no school has as yet *pushed* pupils of great promise in this respect with the intent of developing them into Karl Bitters in this wide field.

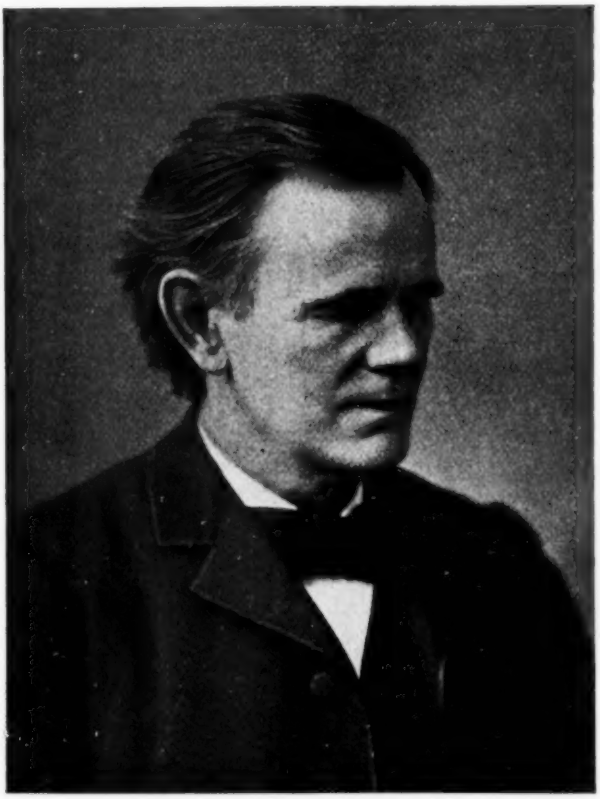
Given damp clay and a specific object to imitate, blind pupils are enabled by constant digital comparison (and their subtle sense of touch is no mean guide) to turn out in clay a very fair reproduction of their stuffed models. Afterward they model from memory, and without opportunities of comparison.

Henry Tschudi, a boy of seventeen, blind from birth, and educated in the American College of Music, passed his examination in June, 1891, in harmony, counterpoint, the history of music, musical form, terminology, acoustics, and the theory and practice of the organ. It was necessary for candidates to play at command compositions of Bach, Handel, Mendelssohn, and other composers, in polyphonic sonata and free forms; also to transpose, to harmonize a figured bass, improvise upon a given theme, and determine pitch tones by ear. The demonstrative examination at the organ was conducted by three experts, and Mr. Tschudi received 92·80 per cent, being the first blind person to pass the examination.

Another pupil, of whom the New York Institution for the Blind is justly proud, is Mr. Lewis B. Carll, also born blind, who was prepared for Columbia College within its walls. He was graduated from Columbia College in 1870, being a classmate of the now president, Mr. Seth Low, and took second place in a class

of thirty. He delivered the class oration. Mr. Carll now lectures at Columbia College twice a week on the Calculus of Variations, and supports himself by giving lessons in mathematics. He lives in New Jersey, and comes to New York every day alone, sometimes going as far as Harlem.

The list which is kept of the occupations followed by pupils after graduation from the New York Institution for the Blind is curious reading. One of the tuners in Steinway's warerooms is



PROF. DAVID D. WOODS.

a graduate, and another graduate was for years organist in Dr. Crosby's church. An insurance broker, a prosperous news vender with three stands, a horse dealer, a tax collector, a real estate agent, a florist, are duly registered. But the most astonishing of all entries are those of a lumberman, a sailor and a cook, and finally a switch-tender.

The Pennsylvania Institute for the Blind, in Philadelphia, points with pride to two very distinguished graduates in the field of music—Mr. David D. Woods (a very excellent likeness of whom is herewith reproduced), the famous blind organist of

St. Stephen's Church in Philadelphia, and Mr. Adam Geibel, composer and organist of the Baptist Temple at Broad and Berks Streets, Philadelphia, and of the John B. Stetson Chapel, at Fourth and Columbia Avenues in the same city.

Prescott the historian and Huber the naturalist were both blind.

The following remarkable instances of deaf persons, many of them congenitally so, who are practicing professions, and depending entirely upon lip-reading for their understanding of conversation, was prepared by a gentleman connected with an institution for the deaf, whose name I am not at liberty to give.

A Columbus paper has published some accounts of the stone-deaf Ohio lawyer, in full practice, who depends absolutely upon lip-reading, and who has tried cases in Columbus courts. For twelve years now, Mr. N. B. Lutes, of Tiffin, Ohio, has depended entirely upon lip-reading to do all that any lawyer does for his clients in court and in every phase of the practice of the law.

The latest issue of the Missouri Deaf-Mute Record gives an account of a lady who reads the lips of ministers and public speakers. Mr. Alexander Hunter, of the United States Land Office, in Washington, D. C., is "deaf as an adder." Though far from perfect in lip-reading, he has read one hundred and fifty words "given out" from the dictionary without making a mistake. He has read the lips of Beecher and Booth almost faultlessly, and has greatly enjoyed pulpit and platform orators and some of the great actors, the chief drawback in reading their lips being the shifting of their positions on the stage, so that their lips were at times invisible.

Mitchell, the chemist, an examiner in the United States Patent Office, graduated from the Clarke Institute, Northampton, Mass., and, though a poor lip-reader, graduated from the Worcester (Mass.) Polytechnic School as an analytical chemist.

For many years a totally deaf man has occupied a place in the United States Civil Service, receiving his first appointment on the strength of admirable papers in the civil-service examination. Notwithstanding his infirmity, thanks to his lip-reading, he took the regular course at a great university, recited with his classmates, attended lectures, and secured his degree. I doubt if president or professors knew that he was a deaf man. Certainly some of his classmates did not know it. For business reasons his deafness is kept secret, and a keen newspaper man went through the office in which he was employed a few years ago in search of a deaf clerk, and failed to find such a man or any one who knew of the existence of such a case in that department.

This, of course, is an extraordinary case, but probably none more so than that of Miss Salter (see Annals of Volta Institute,

Volume XXIII, pages 181–185), so far as proficiency in lip-reading is concerned, or, for that matter, for many other reasons. Then there is the case of the English barrister Lowe, the most learned congenital deaf-mute on record. He was a pupil of the first Watson (who taught by the oral method without recourse to signs, but used the two-handed alphabet). The North British Review said of Lowe, "A stranger might exchange several sentences with him before discovering that he is deaf." Dr.

HELEN KELLER AND HER TEACHER.

H. P. Peet said of him (after an interview), "He certainly uses the English language with an exceptional degree of correctness." The Annals gives a glowing account of Lowe's attainments, in Volume XXII, pages 36–40, abridged from an article in Smith's Magazine, but is silent as to his attainments in speech and lip-reading. Dr. H. P. Peet, in his Tour, says his voice was guttural, and single words were intelligible, though his connected speech was hard to understand. Lowe, in addition to be-

ing a great and successful barrister at law (studying under the learned chief justice), was a master of many languages—French (modern and old), Latin, Greek (ancient and modern), German, Italian, Spanish, Portuguese, Dutch, Danish, with some knowledge of Gaelic, Irish, Welsh, Swedish, Polish, Russian, Bohemian, Finnish, and had not neglected Hindostani and Sanskrit. He commenced Hebrew in his thirty-fifth year, and afterward constantly read the Old Testament in that language. He was also familiar with various branches of science, architecture, etc. The McLellan brothers, both deaf, are successful Canadian lawyers.

The results of competent oral instruction are simply marvelous, students being shown at the Penn Institute for the Deaf, at Mount Airy, Philadelphia, who can understand and repeat, in a fairly modulated voice, long sentences uttered away from them—i. e., when they are only able to perceive the movements of that corner of the speaker's mouth which is toward them—who can also read fluently from the shadow of speaking lips thrown upon the wall. These visual organs of the deaf are made to do the work of two senses, and attain in time the most extraordinary power and even subtlety of vision. It has with propriety been suggested that such highly developed eyes would be of service in the most delicate astronomical and physical experiments, where instruments of precision are commonly employed. A likeness of Helen Keller and one of her teachers accompanies this article. This girl was congenitally deaf and blind, and has been taught to use articulate speech by the oral system of education now so successfully practiced.

By oral instruction I mean that system which teaches the deaf to communicate with the world at large by means of articulate speech, in contradistinction to the inferior and largely discarded manual-alphabet system, which entirely isolates them as a class from society in general, which does not understand their signs and can not spare time to use the writing pad.

THE theory of probability and uniform experience, said Dr. William Harkness, at the American Association, alike show that the limit of accuracy attainable with any instrument is soon reached; and yet we all know the fascination which continually lures us on in our efforts to get better results out of the familiar telescopes and circles which have constituted the standard equipment of observatories for nearly a century. Possibly these instruments may be capable of indicating somewhat smaller quantities than we have hitherto succeeded in measuring with them, but their limit can not be far off, because they already show the disturbing effects of slight inequalities of temperature and other uncontrollable causes. So far as these effects are accidental they eliminate themselves from every long series of observations, but there always remains a residuum of constant error, perhaps quite unsuspected, which gives us no end of trouble.

AN OLD INDUSTRY.

By MARY H. LEONARD.

IN the rich lands along the river banks of South Carolina, particularly in the Peedee section, there could be seen a few years ago an occasional vat or tank, made of the durable cypress timber, and raised high above the ground on wooden posts. Perhaps before the present time the last of these vats has disappeared; yet these recent traces of an old industry tell of a time when the making of indigo was the most important source of wealth of a prosperous colony. For fifty years, extending from a little before the middle of the eighteenth century to its last decade, when the invention of the cotton gin changed the direction of southern enterprise, indigo-making in South Carolina exceeded all other industries in importance.

To-day not an ounce of indigo is prepared for market purposes within the State. The cypress boards of the "beaters" and "steepers" have been converted into other structures. The records of the methods and profits of the industry have been shelved in the archives of the once flourishing Winyaw Indigo Society, whose old hall in Georgetown has been given over to the use of a modern graded school. The wild indigo still grows abundantly in the woods, but its associations are foreign to the thoughts of the present industrial generation.

There are two species of plants native to South Carolina from which indigo for market purposes has sometimes been prepared. The most familiar of these is the *Baptisia tinctoria*, of the order *Leguminosæ*, commonly called "wild indigo," a branching herb with insignificant yellow blossoms and small, bluish-green leaves which blacken in drying. It grows in dry, sandy soil in all the eastern States, and is abundant along the woody roadsides of New England, where it is often picked to put over the heads of horses on the road as a protection against worrying flies.

The other indigo-bearing plant was known as "false indigo" or "bastard indigo." It is the *Amorpha fruticosa*, a shrubby plant, also of the order *Leguminosæ*, but bearing bluish-purple blossoms. A coarse kind of dye was formerly prepared from its young shoots.

In the palmy days of indigo-making the dye generally thought to be of finest quality was obtained from a cultivated plant similar to the "wild indigo"—a native of Hindostan, but introduced into South Carolina from the West Indies. A writer* of the

* This quotation is taken from A Description of South Carolina prepared by Order of Governor Glen, and containing Curious and Interesting Particulars relating to the Civil, Natural, and Commercial History of the Colony within Forty Years (1710–1750).

eighteenth century tells us: "Indigo is of several Sorts. What we have gone mostly upon is the Sort generally cultivated in the Sugar Islands, which requires a high loose Soil, tolerably rich, and is our annual Plant, but the Nilco (i. e., wild) sort which is common in this Country is much more hardy and is perennial. The Stalk dies every year, but it shoots up again next Spring. The Indigo made from it is of as good quality as the other, and it will grow on very indifferent Land, provided it be dry and loose."

Experiments with indigo are noted as early as 1670. The earliest records of the colony contain allusions to "indico" as one of the sources of wealth. After a few years the making of indigo languished for a time. A London writer * of 1682 says: "Indigo they have made, and that good. The reason why they have desisted I can not learn." The industry was revived to some extent in Governor Thomas Smith's administration—the landgrave and wealthy planter who is said to have introduced the rice culture by planting in his garden at Charles-Town a bag of seed rice from Madagascar.

Edisto Island was early given to indigo culture, and the quality of its product became noted. The better soil for the production of indigo led many of the Huguenot immigrants to leave their first home at St. James on the Santee, and settle in St. Stephen's Parish. Yet these early efforts in indigo culture were not a marked success. We are told by an old writer that "all creatures about an indigo plantation are starved, whereas about a rice one, which abounds with provisions for man and beast, they thrive and flourish."

The honor of raising indigo-making to a profitable industry belongs to an enterprising young lady named Eliza Lucas. The story of her efforts is told in Ramsay's History of South Carolina.† George Lucas, the father of Eliza, was Governor of Antigua, in the West Indies, and also the owner of a plantation in South Carolina at Wappoo Cut.

In 1739 the daughter, who had become familiar with the crop and its methods in the West Indies, came to live in South Carolina. Her father often sent to her tropical seeds to be planted for her amusement on the plantation. The fact that a plant similar to the indigo of the West Indies grew spontaneously in the province suggested the adaptedness of the crop to this climate. Accordingly, some seed was sent, which Eliza planted in March,

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* Quotation from A Compleat Discovery of the State of South Carolina, prepared by T. A., Gent, clerk in his Majestie's Ship Richmond, which was sent out in the year 1680 to inquire into the State of that Country by his Majestie's Special Command. To be sold by Mrs. Grover in Pelican Court, Little Britain, 1682.

† See Ramsay's History, vol. ii, p. 138, etc.

1741. It was destroyed by a frost; but in April the experiment was repeated, the second crop being also cut down by a worm. Nothing daunted, the persevering young lady planted for the third time, and the effort proved successful.

When Governor Lucas heard that the plant had seeded and ripened, he sent from Montserrat, at high wages, an indigo-maker, named Cromwell, to show Eliza the process. He built vats on the Wappoo, and made some indigo of indifferent quality. Having repented of his engagement as likely to injure the industry in his own country, he also made a mystery of the process, and tried to deceive by throwing in too much lime. But Eliza, who was watching carefully, detected the deception, and at once engaged a Mr. Deveaux to superintend further attempts at indigo-making.

Not long after these experiments Eliza Lucas married Charles Pinckney, afterward Chief Justice of South Carolina. A generation later, their son—Charles Cotesworth Pinckney—was an illustrious figure in the affairs of the State and nation.

Eliza Lucas brought to her husband as part of her dowry the fruit of her own industry, in the form of all the indigo raised on the plantation. It was saved for seed, and a part was planted the next year on Mr. Pinckney's plantation at Ashepoo. The rest was given to friends, who began making experiments in indigo. Most of these proved successful, and the manufactured product soon became an important article of export.

Miss Lucas, though best known as the introducer of indigo, and the mother of Charles Cotesworth Pinckney, is said to have possessed literary talent as well as executive power. Her letters were afterward privately printed, and one of them, under the title A Love Letter of the Last Century, has been included in Stedman and Hutchinson's Library of American Literature.

The success attending the experiments with imported indigo turned the minds of the people again to the native plants. A Mr. Cattell brought to Mr. Pinckney some of the wild indigo from the woods. Experiments were made, and it was found capable of yielding good indigo, but was less productive than the other. From this time, indigo for home use and for exportation was extensively made from both kinds of plants. Of the women of the Revolution we are told, "Indigo either tame or wild enables them to give a beautiful blue to their homespun."

In 1747 a considerable quantity of indigo was sent to England, which induced the merchants trading to Carolina to petition Parliament for a bounty on Carolina indigo. This petition of the English merchants was followed by another from the planters. Parliament examined the matter, and found that indigo was one of the most beneficial articles of French commerce; that the

West India Islands supplied all the markets of Europe; and that Great Britain alone consumed annually six hundred thousand pounds weight of French indigo, which at five shillings a pound cost England the enormous sum of a hundred and fifty thousand pounds sterling. It was also found that the English West Indies were generally raising sugar cane instead of indigo. Accordingly, in 1748, a bounty was given "of sixpence sterling on all indigo raised in the British-American plantations and imported directly into Great Britain from the place of its growth."

Some years elapsed before the colonists learned the art of making it as well as the French. The planters were blamed by the English merchants for paying too much attention to the quantity and too little to the quality of their indigo, and the West Indian indigo brought a higher price in the market. But each year the skill of the colonists increased, and in process of time they brought indigo-making to such a degree of perfection as not only to supply the mother country but also to undersell the French in several European markets.

In 1748 the amount of indigo exported from South Carolina was 138,118 pounds, which was sold at 2*s.* 6*d.* sterling; in 1754 the export was 216,924 pounds; and shortly before the Revolution it had risen to 1,107,660 pounds.

Various statements regarding the price of indigo are given in the old records. The value varied greatly during the half century of its production. A recent writer* says, "The finest quality of the dye at one time sold in the market for as much as four or five dollars a pound, and fortunes were made rapidly by its cultivation." It is certain that between the years 1763 and 1775, when indigo was at the height of its importance, South Carolina had a most unexampled period of prosperity. Ramsay tells us that "indigo proved more profitable to South Carolina than the mines of Mexico or Peru to Old or New Spain." Wealth poured in upon the people, many of the planters doubling their capital every three or four years. During the years preceding the Revolution† it is said that "a larger number of children were sent to England for education from South Carolina than from any of the colonies, and this on account of the greater wealth of the colony, owing to the superiority of her products—rice and indigo—which gave abundant means."

But the Revolution brought a change in industrial and commercial conditions. During the war more rice was raised than indigo, as was natural. After peace was declared, indigo culture increased again for a little time. But the conditions of trade were different. The English bounty was no longer available.

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* Scott's Random Recollections, etc., 1876.

† See Ramsay's History.

Large importations of indigo soon came to England from the East Indies, which lowered the price, and the palmy days of indigo for South Carolina were gone forever.

As its value declined, other crops took its place. Rice superseded indigo in the coast districts. In North Carolina, where indigo had been extensively raised also, tobacco became the principal export, and was used as a medium of exchange, as indigo had formerly been. But the climax of decline was reached in 1794, when a certain Yankee schoolmaster of Georgia, named Eli Whitney, brought to perfection the saw gin, which relieved the necessity of tedious manual operations in the cleaning of cotton. The value of cotton and of negro labor to cultivate it became suddenly very great. So the reign of indigo passed away; cotton became king, and a new industrial era dawned, leading to tremendous historical consequences in the State and nation.

But although indigo was no longer a staple or article of export, yet during the early part of the nineteenth century it was still produced in small amounts for domestic use. In his Random Recollections of a Long Life, published in 1876, Mr. Edwin J. Scott tells us of the process as he saw it carried on in his boyhood. The plants were immersed in water and the coloring matter extracted. This was allowed to sink by its own weight to the bottom of the vat, when the water was drawn off and the sediment left to harden. He continues: "When broken, the cleavage in good indigo was smooth, and showed a copper-colored tinge. The recipe of a traditional old lady of South Carolina for judging of the quality of indigo is said to have been as follows: 'Take a clean new cedar or cypress piggin; fill it three thirds full with clean spring water; put into it a lump of indigo as big as an egg and if good it will sink or swim, I have forgotten which!'"

But simple as the process sounds in the descriptions of Mr. Scott, the indigo industry was one which involved much risk, and required great skill and untiring attention day and night. Through the whole of the "making season" a periodical change of hands was kept up, except in the case of the "indigo-maker," who, we are told, "could no more leave his post than the captain of a ship on a lee shore."

In his Reminiscences of St. Stephen's Parish,* Mr. Du Bose says: "I have often heard it said that during the manufacturing season Mr. Peter Sinkler [Mr. Du Bose's grandfather, who was an indigo-maker of high reputation] would be three weeks without seeing his wife, though he slept at home every night. He would come home late, when she was asleep, and return to his professional labors before she awoke in the morning."

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* Du Bose's Reminiscences of St. Stephen's Parish, printed in 1852.

The want of success with indigo in the early days was probably owing far more to the imperfect knowledge of the methods of preparation than to the want of the imported seed. It seems to have been usually attempted at first to carry on indigo-making in alternation with other labors.

In an early Description of South Carolina* we read: "One Slave may manage two acres and upwards [of indigo] and raise provisions beside; and have all the Winter Months to saw Lumber and be otherwise employed in."

And again: "I cannot leave this Subject without observing how conveniently and profitably as to the change of Labour both Indigo and Rice may be managed by the same persons: for the Labour attending Indigo being over in the Summer Months, those who are employed in it may afterwards manufacture Rice in the ensuing Part of the Year, when it becomes most laborious; and after doing all this they will have some Time to spare for Sawing Lumber and making Hogshead and other Staves to supply the Sugar Colonies."

In its best days indigo-making was a profession absorbing all the thought of an entire plantation.

An extended list of "Rules and Directions as practiced by an ingenious Person who practiced them with much Success" is given in Dr. Hewit's Historical Account of South Carolina and Georgia.† Another even more explicit description of the processes used is given by Du Bose in his Reminiscences. From these and other sources the following details of methods in vogue among professionals have been compiled:

The ground to be planted was plowed or turned up with hoes some time in December, that the frost might render it rich and mellow. Afterward it was harrowed, cleaned from all roots, grass, etc., well drained, and thoroughly pulverized. After all danger of frost was over—in South Carolina about the beginning of April—the fields were laid off in drills about an inch deep and twelve to fifteen inches apart. In these drills the seeds, mixed with lime and ashes, were sown.

Mr. Hewit tells us: "The next thing to be considered is the choice of seed, in which the planters should be very nice. There is great variety of it, and from every one good indigo may be made, but none answers so well in this colony as the true Gautimala, which if good is a small, oblong black seed, very bright and full, and when rubbed in the hand will appear as if highly polished. A bushel of seed will sow four English acres."

If the season was a fair one, the seeds came up in ten days or

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* Same book referred to in the first note of this article.

† Included in Carroll's Historical Collections.

a fortnight, and grew rapidly, requiring nice and frequent hoeing and weeding. The plants were usually cut three or four times in the season. Whenever the plant was in full bloom it required to be cut down without regard to height, as the leaves were then thick and full of juice.

The plants were cut with a reaping hook and carried to the macerating vat, also called the "steeper." This, as well as a second vat called the "beater," was "made of the best cypress or yellow-pine planks, well fastened to the joints and studs by spikes and then calked."

When the steeper was furnished with a sufficient quantity of weed, clean water was poured in, and the weeds were left to steep or macerate until all the coloring matter was extracted. The weed was laid regularly in the steeper with the stalk upward, and upon it long rods were fastened lengthwise in the vat to prevent its buoying up when the water was pumped in. Soft water was needed for the purpose, and the quantity must be just enough to cover all the weed. This process of "steeping" or fermentation usually took from twelve to fifteen hours.

The fluid was then drawn off into the beater, where it was agitated violently until all the coloring matter was united in a body. The usual contrivance for this purpose consisted of an axle, to which were attached long arms, each furnished with a small bucket at the end. The laborer would place himself upon the vat, and work the axle with a handle or crank, causing the buckets to rise and fall rapidly in the liquid. This process of "beating" required great nicety, for if not continued long enough a part of the tingeing matter remained in the water; if continued too long, a part of that which had separated was dissolved afresh.

Du Bose tells us: "I can well remember how often in the process the liquor was taken up in a plate and anxiously examined in the rays of the sun to ascertain whether all the particles of dye were separated; for if not, the result would be a failure; the bright true-blue color would not be obtained, and the value of the drug would be impaired."

Lime was then applied, which assisted in the separation of the water from the indigo. The whole was allowed to rest eight or ten hours, until the blue matter had thoroughly settled. The clean water was then drawn off by cocks in the sides, at different heights, and the blue part was discharged by a cock in the bottom into another vat. It was strained through a horsehair sieve, and afterward put into bags "made of osnaburgs, eighteen inches long and twelve inches wide," and suspended for six hours to drain. After this, the mouths of the bags being well fastened, they were put into a press to complete the removal of the water.

The indigo had now become a fine stiff paste which was cut

into pieces about two inches square and laid out to dry. The drying house was made of logs so arranged as to allow free access of air without exposure to the sun, "which was very pernicious to the dye"; as indigo, if placed in the sun, "in a few hours would be burnt up to a perfect cinder." While in the drying house the indigo was carefully turned three or four times a day to prevent it from "rotting." Care was also taken to keep away flies, since "at this season of the year they are hatched in millions and infect an indigo plantation like a plague." Care was also necessary that the indigo should be sufficiently dry before being packed, lest after it was headed up in barrels it should "sweat" and so become spoiled for the market. In packing the indigo the lumps were brushed to make them look as bright as possible.

While the indigo was curing it had an offensive smell, and we read that "as the dregs of the weed are full of salts and make excellent manure they should be immediately buried underground when brought out of the 'steeper.'"

The season for making indigo in Carolina ended with the beginning of frosty weather, and the planters brought their indigo to market about the end of the year. The merchants judged of its quality by breaking it and observing the closeness of the grain and the brilliant copper or violet-blue color. The weight also showed the quality, for heavy indigo of every color was always bad. Fire afforded another test, as good indigo was almost entirely consumed, but the bad would leave a quantity of ashes.

Probably these numerous details in the process were abbreviated by many of the indigo-makers. But there were many grades of professional reputation among indigo planters, dependent on the nicety of their work.

In addition to the risks attending the manufacture of indigo, there were others connected with the growth of the crop. Du Bose writes: "The great enemy of the crop was the grasshopper, which would sometimes destroy the crop in a few days. The best remedy against this enemy was chickens. I recollect that my father was in the habit every year of sending into the swamp fields several hundred chickens. Movable coops were furnished for their accommodation by night, but no food. Nor did they require any so long as the grasshopper infested the fields. Those who could not use chickens suffered the margins of their fields to grow up to grass. The grasshoppers, driven from the fields with whipping brushes, would alight in the grass, which was then fired."

The indigo for exportation was brought into Charles-Town in wagons, and the owners received the proceeds in the form of Spanish silver coin, which composed almost the entire currency before the Bank of the State was established in 1812. It was a

clumsy and inconvenient medium of exchange for large amounts. We read that "the merchants of North Carolina and other distant points used to carry the money in boxes fitting under the seats of the 'sulkies' in which they traveled, so as to be taken out at night and put back in the morning."

The indigo itself was often used directly as a medium of purchase for other commodities. General Harrington at one time sent three four-horse wagonloads of indigo to Virginia, buying in exchange from fifteen to twenty negroes.

An interesting illustration of this use of indigo is connected with General Francis Marion. The incident occurred in 1783, just after the battle of Hobkirk Hill. A nephew of General Marion was to be sent to school in Philadelphia, and was accordingly fitted out with a wagonload of indigo which was to pay for his tuition and other school expenses. As the British then held possession, General Marion wrote * to Lord Balfour in command in Charles-Town, asking a permit for the boy to pass through the British lines. General Marion's letter was sent by Balfour to Rawdon and was afterward countersigned by Cornwallis. The youth with his wagonload of indigo was allowed to proceed by the Charlotte route toward Philadelphia, but unfortunately he died before reaching his destination.

The history of the indigo industry would not be complete without a description of the old Winyaw Indigo Society of Georgetown. This society, named from the tribe of Indians who once occupied this part of the State, was originally a social club formed in 1740 by the planters of the Georgetown district. It met once a month to discuss the latest news from London, and also certain agricultural questions. The society was not incorporated until some years later, and then took the name "Winyaw Indigo Society," having in view the improvement of the indigo industry, and also certain educational aims.

The annual fees of the members were paid in indigo, and, as the expenses were light there had accumulated in 1753 a sum which seemed to require some special application. The president proposed that the surplus fund should be devoted to the establishment of a charity school for the poor. Ramsay tells us, nearly fifty years later: "The object of this society is now wholly confined to the education of orphan children. Since its commencement there have been educated and supported by its bounty between one hundred and two hundred children. From the continual accession of new members the funds are in a flourishing condition and enable the society to educate twenty children annually." The

* This interesting letter of General Marion's is now in the possession of Mr. Richardson, of Sumter, S. C.

school had a growing reputation, and afterward enlarged the sphere of its benefits. It was for many years one of the chief schools in the eastern part of the State, and was resorted to by all classes.

The society * also accumulated a valuable library, which was added to and maintained until destroyed by the Federal troops on the occupation of Georgetown during the civil war. Also during the war the school itself was discontinued.

The Winyaw Indigo Society still exists in Georgetown as a social club, but has no connection with indigo except in name. The old hall of the society is now occupied by the public graded schools of Georgetown.

Thus a new social and industrial order has established itself upon the old. The children of these schools to-day know nothing of indigo. The process of its manufacture, once so important, is now forgotten. But to the traveler through the country the branching herbs of the wayside with their bluish-green leaves are eloquent with the memories of an era long past, and of a forgotten industry whose records are hidden away within the pages of a few obscure old volumes.

THE SCIENTIFIC WORK OF TYNDALL.

By the Right Hon. LORD RAYLEIGH, F. R. S., etc.,
PROFESSOR OF NATURAL PHILOSOPHY, ROYAL INSTITUTION OF GREAT BRITAIN.

IT is fitting that the present season should not pass without a reference on these evenings to the work of him whose tragic death a few months since was felt as a personal grief and loss by every member of the Royal Institution. With much diffidence I have undertaken the task to-night, wishing that it had fallen to one better qualified by long and intimate acquaintance to do justice to the theme. For Tyndall was a personality of exceeding interest. He exercised an often magical charm upon those with whom he was closely associated, but when his opposition was aroused he showed himself a keen controversialist. My subject of to-night is but half the story.

Even the strictest devotion of the time at my disposal to a survey of the scientific work of Tyndall will not allow of more than a very imperfect and fragmentary treatment. During his thirty

* An account of the Winyaw Indigo Society, and the school established by it, is given in a Paper on Colonial Education in South Carolina, read before the South Carolina Historical Society, August 6, 1883, by Edward McCrady, Jr., and afterward published in vol. iv of the Collections of the Historical Society of South Carolina.

years of labor within these walls he ranged over a vast field, and accumulated results of a very varied character, important not only to the cultivators of the physical sciences, but also to the biologist. All that I can hope to do is to bring back to your recollection the more salient points of his work, and to illustrate them where possible by experiments of his own devising.

In looking through the catalogue of scientific papers issued by the Royal Society, one of the first entries under the name of Tyndall relates to a matter comparatively simple, but still of some interest. It has been noticed that when a jet of liquid is allowed to play into a receiving vessel, a good deal of air is sometimes carried down with it, while at other times this does not happen. The matter was examined experimentally by Tyndall, and he found that it was closely connected with the peculiar transformation undergone by a jet of liquid which had been previously investigated by Savart. A jet as it issues from the nozzle is at first cylindrical, but after a time it becomes what the physiologists call *varicose;* it swells in some places and contracts in others. This effect becomes more exaggerated as the jet descends, until the swellings separate into distinct drops, which follow one another in single file. Savart showed that under the influence of vibration the resolution into drops takes place more rapidly, so that the place of resolution travels up closer to the nozzle.

Tyndall's observation was that the carrying down of air required a jet already resolved into drops when it strikes the liquid. I hope to be able to show you the experiment by projection upon the screen. At the present moment the jet is striking the water in the tank previons to resolution into drops, and is therefore carrying down no air. If I operate on the nozzle with a vibrating tuning fork, the resolution occurs earlier, and the drops now carry down with them a considerable quantity of air.

Among the earlier of Tyndall's papers are some relating to ice, a subject which attracted him much, probably from his mountaineering experiences. About the time of which I am speaking Faraday made interesting observations upon a peculiar behavior of ice, afterward called by the name of regelation. He found that if two pieces of ice were brought into contact they stuck or froze together. The pressure required to produce this effect need not be more than exceedingly small. Tyndall found that if fragments of ice are squeezed they pack themselves into a continuous mass. We have here some small ice in a mold, where it can be subjected to a powerful squeeze. The ice under this operation will be regelated, and a mass obtained which may appear almost transparent, and as if it had never been fractured at all. The flow of glaciers has been attributed to this action, the fractures which the stresses produce being mended again by regelation. I

should say, perhaps, that the question of glacier motion presents difficulties not yet wholly explained. There can be no doubt, however, that regelation plays an important part.

Another question treated by Tyndall is the manner in which ice first begins to melt under the action of a beam of light passing into it from an electric lamp. Ice usually melts by conducted heat, which reaches first the outside layers. But if we employ a beam from an electric lamp, the heat will reach the ice not only outside but internally, and the melting will begin at certain points in the interior. Here we have a slab of ice which we project upon the screen. We see that the melting begins at certain points, which develop a crystallized appearance resembling flowers. They are points in the interior of the ice, not upon the surface. Tyndall found that when the ice gives way at these internal points there is a formation of apparently empty space. He carefully melted under water such a piece of ice, and found that when the cavity was melted out there was no escape of air, proving that the cavity was really vacuous.

Various speculations have been made as to the cause of this internal melting at definite points, but here again I am not sure if the difficulty has been altogether removed. One point of importance brought out by Tyndall relates to the plane of the flowers. It is parallel to the direction in which the ice originally froze—that is, parallel to the original surface of the water from which it was formed.

I must not dwell further upon isolated questions, however interesting, but will pass on at once to our main subject, which may be divided into three distinct parts, relating namely to heat, especially dark radiation, sound, and the behavior of small particles, such as compose dust, whether of living or dead matter.

The earlier publications of Tyndall on the subject of heat are for the most part embodied in his work entitled Heat as a Mode of Motion. This book has fascinated many readers. I could name more than one now distinguished physicist who drew his first scientific nutriment from it. At the time of its appearance the law of the equivalence of heat and work was quite recently established by the labors of Mayer and Joule, and had taken firm hold of the minds of scientific men; and a great part of Tyndall's book may be considered to be inspired by and founded upon this first law of thermodynamics. At the time of publication of Joule's labors, however, there seems to have been a considerable body of hostile opinion, favorable to the now obsolete notion that heat is a distinct entity called caloric. Looking back, it is a little difficult to find out who were responsible for this reception of the theory of caloric. Perhaps it was rather

the popular writers of the time than the first scientific authorities. A scientific worker, especially if he devotes himself to original work, has not time to examine for himself all questions, even those relating to his own department, but must take something on trust from others whom he regards as authorities. One might say that a knowledge of science, like a knowledge of law, consists in knowing where to look for it. But even this kind of knowledge is not always easy to obtain. It is only by experience that one can find out who are most entitled to confidence. It is difficult now to understand the hesitation that was shown in fully accepting the doctrine that heat is a mode of motion, for all the great authorities, especially in England, seem to have favored it. Not to mention Newton and Cavendish, we have Rumford making almost conclusive experiments in its support, Davy accepting it, and Young, who was hardly ever wrong, speaking of the antagonistic theory almost with contempt. On the Continent perhaps, and especially among the French school of chemists and physicists, caloric had more influential support.

As has been said, a great part, though not the whole, of Tyndall's work was devoted to the new doctrine. Much relates to other matters, such as radiant heat. Objection has been taken to this phrase, not altogether without reason; for it may be said that when heat it is not radiant, and while radiant it is not heat. The term dark radiation, or dark radiance as Newcombe calls it, is preferable, and was often used by Tyndall. If we analyze, as Newton did, the components of light, we find that only certain parts are visible. The invisible parts produce, however, as great, or greater, effects in other ways than do the visible parts. The heating effect, for example, is vastly greater in the invisible region than in the visible. One of the experiments that Tyndall devised in order to illustrate this fact I hope now to repeat. He found that it was possible by means of a solution of iodine in bisulphide of carbon to isolate the invisible rays. This solution is opaque to light; even the sun could not be seen through it; but it is very fairly transparent to the invisible ultra-red radiation. By means of a concave reflector I concentrate the rays from an arc lamp. In their path is inserted the opaque solution, but in the focus of invisible radiation the heat developed is sufficient to cause the inflammation of a piece of gun cotton.

Tyndall varied this beautiful experiment in many ways. By raising to incandescence a piece of platinum foil, he illustrated the transformatiom of invisible into visible radiation.

The most important work, however, that we owe to Tyndall in connection with heat is the investigation of the absorption by gaseous bodies of invisible radiation. Melloni had examined the behavior of solid and liquid bodies, but not of gaseous. He

found that transparent bodies like glass might be very opaque to invisible radiation. Thus, as we all know, a glass screen will keep off the heat of a fire, while if we wish to protect ourselves from the sun, the glass screen will be useless. On the other hand, rock salt freely transmitted invisible radiation. But nothing had been done on the subject of gaseous absorption, when Tyndall attacked this very difficult problem. Some of his results are shown in the accompanying table. The absorption of the ordinary non-condensable, or rather not easily condensable, gases—for we must not talk of non-condensable gases now, least of all in this place—the absorption of these gases is very small; but when we pass to the more compound gases, such as nitric oxide, we find the absorption much greater, and in the case of olefiant gas we see that the absorbing power is as much as 6,000 times that of the ordinary gases.

	Relative Absorption at 1 inch Pressure.
Air	1
Oxygen	1
Nitrogen	1
Hydrogen	1
Carbonic acid	972
Nitric oxide	1,090
Ammonia	5,460
Olefiant gas	6,030

There is one substance as to which there has been a great diversity of opinion—aqueous vapor. Tyndall found that aqueous vapor exercises a strong power of absorption—strong relatively to that of the air in which it is contained. This is of course a question of great importance, especially in relation to meteorology. Tyndall's conclusions were vehemently contested by many of the authorities of the time, among whom was Magnus, the celebrated physicist of Berlin. With a view to this lecture I have gone somewhat carefully into this question, and I have been greatly impressed by the care and skill showed by Tyndall, even in his earlier experiments upon this subject. He was at once sanguine and skeptical—a combination necessary for success in any branch of science. The experimentalist who is not skeptical will be led away on a false tack and accept conclusions which he would find it necessary to reject were he to pursue the matter further; if not sanguine, he will be discouraged altogether by the difficulties encountered in his earlier efforts, and so arrive at no conclusion at all. One criticism, however, may be made. Tyndall did not at first describe with sufficient detail the method and the precautions which he used. There was a want of that precise information necessary to allow another to follow in his steps. Perhaps this may have been due to his literary instinct,

which made him averse from overloading his pages with technical experimental details.

The controversy above referred to I think we may now consider to be closed. Nobody now doubts the absorbing power of aqueous vapor. Indeed, the question seems to have entered upon a new phase; for in a recent number of Wiedemann's Annalen, Paschen investigates the precise position in the spectrum of the rays which are absorbed by aqueous vapor.

I can not attempt to show you here any of the early experiments on the absorption of vapors. But some years later Tyndall contrived an experiment, which will allow of reproduction. It is founded on some observations of Graham Bell, who discovered that various bodies became sonorous when exposed to intermittent radiation.

The radiation is supplied from incandescent lime, and is focused by a concave reflector. In the path of the rays is a revolving wheel provided with projecting teeth. When a tooth intervenes, the radiation is stopped; but in the interval between the teeth the radiation passes through, and falls upon any object held at the focus. The object in this case is a small glass bulb containing a few drops of ether, and communicating with the ear by a rubber tube. Under the operation of the intermittent radiation the ether vapor expands and contracts; in other words, a vibration is established, and a sound is heard by the observer. But if the vapor were absolutely diathermanous, no sound would be heard.

I have repeated the experiment of Tyndall which allowed him to distinguish between the behavior of ordinary air and dry air. If, dispensing with ether, we fill the bulb with air in the ordinary moist state, a sound is heard with perfect distinctness, but if we drop in a little sulphuric acid, so as to dry the air, the sound disappears.

According to the law of exchanges, absorption is connected with radiation; so that while hydrogen and oxygen do not radiate, from ammonia we might expect to get considerable radiation. In the following experiment I aim at showing that the radiation of hot coal gas exceeds the radiation of equally hot air.

The face of the thermopile, protected by screens from the ball itself, is exposed to the radiation from the heated air which rises from a hot copper ball. The effect is manifested by the light reflected from a galvanometer mirror. When we replace the air by a stream of coal gas, the galvanometer indicates an augmentation of heat, so that we have before us a demonstration that coal gas when heated does radiate more than equally hot air, from which we conclude that it would exercise more absorption than air.

I come now to the second division of my subject, that relating to sound. Tyndall, as you know, wrote a book on sound, founded on lectures delivered in this place. Many interesting and original discoveries are there embodied. One, that I have been especially interested in myself, is on the subject of sensitive flames. Prof. Le Conte in America made the first observations at an amateur concert, but it was Tyndall who introduced the remarkable high-pressure flame now before you. It issues from a pinhole burner, and the sensitiveness is entirely a question of the pressure at which the gas is supplied. Tyndall describes the phenomenon by saying that the flame under the influence of a high pressure is like something on the edge of a precipice. If left alone, it will maintain itself; but under the slightest touch it will be pushed over. The gas at high pressure will, if undisturbed, burn steadily and erect, but if a hiss is made in its neighborhood it becomes at once unsteady, and ducks down. A very high sound is necessary. Even a whistle, as you see, does not act. Smooth, pure sounds are practically without effect unless of very high pitch.

I will illustrate the importance of the flame as a means of investigation by an experiment in the diffraction of sound. I have here a source of sound, but of pitch so high as to be inaudible. The waves impinge perpendicularly upon a circular disk of plate glass. Behind the disk there is a sound shadow, and you might expect that the shadow would be most complete at the center. But this is not so. When the burner occupies this position the flame flares; but when by a slight motion of the disk the position of the flame is made eccentric, the existence of the shadow is manifested by the recovery of the flame. At the center the intensity of sound is the same as if no obstacle were interposed.

The optical analogue of the above experiment was made at the suggestion of Poisson, who had deduced the result theoretically, but considered it so unlikely that he regarded it as an objection to the undulatory theory of light. Now, I need hardly say, it is regarded as a beautiful confirmation.

It is of importance to prove that the flame is not of the essence of the matter, that there is no need to have a flame, or to ignite it at the burner. Thus, it is quite possible to have a jet of gas so arranged that ignition does not occur until the jet has lost its sensitiveness. The sensitive part is that quite close to the nozzle, and the flame is only an indicator. But it is not necessary to have any kind of flame at all. Tyndall made observations on smoke jets, showing that a jet of air can be made sensitive to sound. The difficulty is to see it, and to operate successfully upon it; because, as Tyndall soon found, a smoke jet is much more difficult to deal with than flames, and is sensitive to much

graver sounds. I doubt whether I am wise in trying to exhibit smoke jets to an audience, but I have a special means of projection by which I ought at least to succeed in making them visible. It consists in a device by which the main part of the light from the lamp is stopped at the image of the arc, so that the only light which can reach the screen is light which by diffusion has been diverted out of its course. Thus we shall get an exhibition of a jet of smoke upon the screen, showing bright on a dark ground. The jet issues near the mouth of a resonator of pitch 256. When undisturbed, it pursues a straight course and remains cylindrical. But if a fork of suitable pitch be sounded in the neighborhood, the jet spreads out into a sort of fan, or even bifurcates, as you see upon the screen. The real motion of the jet can not, of course, be ascertained by mere inspection. It consists in a continuously increasing *sinuosity*, leading after a while to complete disruption. If two forks slightly out of unison are sounded together, the jet expands and re-collects itself, synchronously with the audible beats. I should say that my jet is a very coarse imitation of Tyndall's. The nozzle that I am using is much too large. With a proper nozzle, and in a perfectly undisturbed atmosphere—undisturbed not only by sounds, but free from all draughts—the sensitiveness is wonderful. The slightest noise is seen to act instantly and to bring the jet down to a fraction of its former height.

Another important part of Tyndall's work on sound was carried out as adviser of the Trinity House. When in thick weather the ordinary lights fail, an attempt was made to replace them with sound signals. These are found to vary much in their action, sometimes being heard to a very great distance, and at other times failing to make themselves audible even at a moderate distance. Two explanations have been suggested, depending upon acoustic refraction and acoustic reflection.

Under the influence of variations of temperature refraction occurs in the atmosphere. For example, sound travels more quickly in warm than in cold air. If, as often happens, it is colder above, the upper part of the sound wave tends to lag behind, and the wave is liable to be tilted upward and so to be carried over the head of the would-be observer on the surface of the ground. This explanation of acoustic refraction by variation of temperature was given by Prof. Osborne Reynolds. As Sir G. Stokes showed, refraction is also caused by wind. The difference between refraction by wind and by temperature variations is that in one case everything turns upon the direction in which the sound is going, while in the second case this consideration is immaterial. The sound is heard by an observer down wind, and not so well by an observer up wind. The explanation by refraction

of the frequent failure of sound signals was that adopted by Prof. Henry in America, a distinguished worker upon this subject. Tyndall's investigations, however, led him to favor another explanation. His view was that sound was actually reflected by atmospheric irregularities. He observed, what appears to be amply sufficient to establish his case, that prolonged signals from fog sirens give rise to echoes audible after the signal has stopped. This echo was heard from the air over the sea, and lasted in many cases a long time, up to fifteen seconds. There seems here no alternative but to suppose that reflection must have occurred internally in the atmosphere. In some cases the explanation of the occasional diminished penetration of sound seems to be rather by refraction, and in others by reflection.

Tyndall proved that a single layer of hot air is sufficient to cause reflection, and I propose to repeat his experiment. The source of sound, a toy reed, is placed at one end of one metallic tube, and a sensitive flame at one end of a second. The opposite ends of these tubes are placed near each other, but in a position which does not permit the sound waves issuing from the one to enter the other directly. Accordingly, the flame shows no response. If, however, a pane of glass be held suitably, the waves are reflected back and the flame is excited. Tyndall's experiment consists in the demonstration that a flat gas flame is competent to act the part of a reflector. When I hold the gas flame in the proper position, the percipient flame flares; when the flat flame is removed or held at an unsuitable angle, there is almost complete recovery.

It is true that in the atmosphere no such violent transitions of density can occur as are met with in a flame; but, on the other hand, the interruptions may be very numerous, as is indeed rendered probable by the phenomena of stellar scintillation.

The third portion of my subject must be treated very briefly. The guiding idea of much of Tyndall's work on atmospheric particles was the application of an intense illumination to render them evident. Fine particles of mastic, precipitated on admixture of varnish with a large quantity of water, had already been examined by Brücke. Chemically precipitated sulphur is convenient, and allows the influence of size to be watched as the particles grow. But the most interesting observations of Tyndall relate to precipitates in gases caused by the chemical action of the light itself. This may be illustrated by causing the concentrated rays of the electric lamp to pass through a flask containing vapor of peroxide of chlorine. Within a few seconds dense clouds are produced.

When the particles are very small in comparison with the

wave length, the laws governing the dispersion of the light are simple. Tyndall pursued the investigation to the case where the particles have grown beyond the limit above indicated, and found that the polarization of the dispersed light was effected in a peculiar and interesting manner.

Atmospheric dust, especially in London, is largely organic. If, following Tyndall, we hold a spirit lamp under the track of the light from the electric lamp, the dark spaces, resulting from the combustion of the dust, have all the appearance of smoke.

In confined and undisturbed spaces the dust settles out. I have here a large flask which has been closed for some days. If I hold it to the lamp, the track of the light, plainly visible before entering and after leaving the flask, is there interrupted. This, it will be evident, is a matter of considerable importance in connection with organic germs.

The question of the spontaneous generation of life occupied Tyndall for several years. He brought to bear upon it untiring perseverance and refined experimental skill, and his results are those now generally accepted. Guarding himself from too absolute statements as to other times and other conditions, he concluded that under the circumstances of our experiments life is always founded upon life. The putrefaction of vegetable and animal infusions, even when initially sterilized, is to be attributed to the intrusion of organic germs from the atmosphere.

The universal presence of such germs is often regarded as a hypothesis difficult of acceptance. It may be illustrated by an experiment from the inorganic world. I have here, and can project upon the screen, glass pots, each containing a shallow layer of a supersaturated solution of sulphate of soda. Protected by glass covers, they have stood without crystallizing for forty-eight hours. But if I remove the cover, a few seconds or minutes will see the crystallization commence. It has begun, and long needles are invading the field of view. Here it must be understood that with a few exceptions, the crystalline germ required to start the action must be of the same nature as the dissolved salt; and the conclusion is that small crystals of sulphate of soda are universally present in the atmosphere.

I have now completed my task. With more or less success I have laid before you the substance of some of Tyndall's contributions to knowledge. What I could not hope to recall was the brilliant and often poetic exposition by which his vivid imagination illumined the dry facts of science. Some reminiscences of this may still be recovered by the reader of his treatises and memoirs; but much survives only as an influence exerted upon the minds of his contemporaries, and manifested in subsequent advances due to his inspiration.

THE HIGHEST MOUNTAIN ASCENT AND THE EFFECTS OF RAREFIED AIR.

By EDWIN SWIFT BALCH.

IN 1855 the brothers Adolph and Robert Schlagintweit reached an altitude that for many years was unapproached. This was in a partial ascent of the Ibi Gamin or Kamet Mountain on the southern frontier of Tibet. They traveled up a long glacier by easy stages and encamped at gradually increasing elevations. Their highest camp was 19,360 feet above the sea, and the greatest height they reached on their final effort, 22,250 feet.

Between the years 1860 and 1865 Mr. W. H. Johnson, of the Indian Survey, reached some very great altitudes in Cashmere, for which he has never had due justice done him. Colonel Montgomarie, in receiving from the Royal Geographical Society a reward for Mr. Johnson, made the following statement: "The occasion of Mr. Johnson's (1864) ascending to 22,300 feet was owing to his inability to get at a valley in any other way except by crossing a ridge which reached this altitude. He actually forced his way over, and was obliged to spend the night at nearly 22,000 feet above the sea, darkness having come on before he got any lower." In 1865 Mr. Johnson climbed three peaks of the Kuen Lun, one of which, according to the measurement of the Indian Survey—by a single observation, however—is put down at 23,890 feet. Mr. Johnson seems never to have written any account of his ascents, and in the opinion of the Indian Department it was considered as probable that the single unverified determination of height was erroneous rather than that Mr. Johnson should have ascended to nearly 24,000 feet without special difficulty, and the determination was therefore omitted in compiling the synopsis of final data for publication.

In the year 1884 the little world of Alpine climbers was startled by the narrative read before the Royal Geographical Society by Mr. W. W. Graham, describing a journey to the Sikhim Himalaya, in which with Emil Boss, proprietor of the Hotel Bär at Grindelwald, and the well-known guide, Ulrich Kaufmann, he claimed to have reached in the preceding October the height of 24,000 feet on Mount Kabru. The whole Anglo-Indian press and Himalayan Survey, prompted by jealousy at an English climber with two Swiss guides leaving their efforts so far behind, with great unanimity attacked Mr. Graham's assertions most bitterly. Their arguments are very curious. One of them was that the Bhooteas, natives of the neighboring valleys, stated that they would not attempt the ascent under any circumstances; and yet it was argued that if any one could make the ascent it would cer-

tainly be the Bhooteas, for one of the women once carried a grand piano on her back forty-six miles in three days. This is equivalent to saying that a hotel porter would be the best guide on a mountain side. One of the Indian surveyors, Mr. Roberts, said it would be impossible to ascend Kabṛu, "as no one can avoid the almost certain consequences of an attempt to clamber over sharp ledges of rock and of the yielding of the snow coating that covers over a concealed crevasse." What almost certain consequences clambering over sharp ledges of rock should entail, except, perhaps, barking the climber's shins or tearing his knickerbockers, is a still unsolved riddle, and evidently the Indian Survey has never even heard of using a rope on a glacier.

Then, again, Mr. Graham was attacked about Pandim, a mountain 22,018 feet in height, which the Anglo-Indian press said the natives denied he had ascended. His character for veracity was called in question. The beauty of this attack lay in the fact that he never claimed to have ascended Pandim; on the contrary, he said in his report: "I do not know of any more formidable peak. On the west side it drops sheer, while the other three are guarded by the most extraordinary overhanging glaciers which quite forbid any attempt." Mr. Graham also announced his discovery of two peaks from Kabru, the one a rock peak, the other a snow peak, which seemed higher than Gaurisankar. The Indian Survey taxed this as being no discovery on his part, because the following February a survey party saw peaks which are assumed to be identical with those of Mr. Graham, and which the surveyors thought would prove higher than any mountain yet measured.

Mr. Douglas W. Freshfield, the present secretary of the Royal Geographical Society, aroused by the general foolishness of the Indian Survey, took up the cudgels in behalf of Mr. Graham, and a war on paper resulted in the pretty general acceptance of the reality of his ascent.

Since Mr. W. M. Conway's exploration in the Karakorums, however, the whole question has been reopened, Mr. Edward Whymper, the first climber of the Matterhorn, coming forward especially on account of his disbelief that any one could reach 24,000 feet without extreme suffering from rarefied air. Mr. Graham in his narrative states that neither he nor his Swiss companions "suffered any inconvenience from breathing other than the panting inseparable from any great muscular exertion. Headaches, nausea, bleeding at the nose, temporary loss of sight and hearing, were conspicuous only by their absence; and the only organ perceptibly affected was the heart, whose beatings became very perceptible, quite audible, while the pace was decidedly increased." Mr. Conway, on the contrary, states that "when 18,000 feet had been passed, we found that it was well to look to our

breathing. A long stride had to be taken, and one went at it as usual with a momentary holding of the breath. The penalty was instantly exacted—a giddiness supervened, and had to be puffed and pumped away." Mr. Conway's greatest altitude on the Pioneer Peak was 22,500 feet, which is believed to be the greatest altitude from which an observation on the spot was ever taken. The difficulty in reconciling Mr. Graham's and Mr. Conway's narrative lies especially in the fact that all of Mr. Conway's party suffered—Englishmen, Swiss guide, and Ghoorkas—while none of Mr. Graham's party were affected.

This question of loss of breath at great altitudes can not, however, be taken as a sure test of the height reached. The state of health of the climbers, and whether they are in proper training or not, whether they have had a sufficiency of food, and the different states of the weather are very large factors in the comforts or discomforts of an ascent. Count Henry Russell, one of the most experienced of mountaineers, suffered severely on Mont Blanc (15,800 feet), while Mr. Henry Gale Gotch, after an easy ascent of the same mountain, tried the experiment of jumping a number of times over an alpenstock, which he did without any inconvenience whatever—his guide, Henri Dévouassoud, however, confiding to him after a few days his abiding astonishment at so peculiar a mode of resting after an ascent. Mr. Whymper and the Carrels suffered severely on Chimborazo (21,424 feet), while on the other hand Dr. Güssfeldt on Aconcagua reached 21,000 feet without suffering any inconvenience; and Mr. Freshfield's party of six did not suffer in any way from the air, though they almost ran up the last rocks of Elbruz (18,526 feet).

As the question now stands, we can not be certain which is the highest mountain ascent. There are certainly mistakes in the measurements of the Indian Survey. Peak K 2, Mr. Conway's "Watch Tower," will have to come down from its 28,200 feet to something nearer 27,700 feet; and it is quite possible that too high a measurement may have been given to Kabru, which has not been measured either by mountain barometer or boiling-point thermometer. It is not impossible that Mr. Graham may have been mistaken in his peak, and gone up some other mountain instead. If Mr. Johnson had been a less reticent man than he is described as being, and if more were known of his ascents, he might be a possible claimant for the record. The careful notes on breathing made by Mr. Conway, however, prove pretty conclusively that beyond 21,000 feet every one will, at any rate at certain times, suffer more or less from want of air, and the general feeling in the Alpine Club at present is that Mr. Conway has the highest established record.

BOOKBINDING: ITS PROCESSES AND IDEAL.*

By T. J. COBDEN-SANDERSON.

BOOKBINDING is in itself a comparatively simple matter and is easily described: but it is associated with great and interesting conditions of society, and at its highest rises into disinterested admiration by such means of expression as are within its reach of what is most beautiful and wonderful in human achievement, the written and printed speech of man. Binding, moreover, like every other handicraft, is on its ideal side a discipline and a type of life. I propose, therefore, to explain indeed how a book is bound, and how, when bound, it may be tooled. But I propose also throughout to set the craft into imaginative sympathy with the thought it would perpetuate; to touch upon its origin, its history, and its patrons; to characterize the styles of the great periods of tooled decoration; to insist upon the need of some new departure in the invention and development of pattern; and finally, leaving the special objects of the binder's craft, to find in the intuition of the harmony of the universe an outline of the ideal of the craftsman and of the artist.

Speaking generally, binding has its origin in the desire to perpetuate thought. Before the discovery or invention of pliable portable material suitable for writing upon, "binding" was sought for and found in imperishable natural objects, stones, tablets, columns, ready to hand, upon which the thought was permanently incised. In this case the binding may be said to have preceded the writing. It was only when writing was made upon separate pieces or sheets of a pliable and perishable material that binding proper was invented to hold the pieces or sheets together and to give strength to them, and protection and beauty.

But here again a distinction must be made. The pliable written sheet may be either *rolled* or *folded*, each giving rise to a form of binding peculiar to itself. The rolled sheet is bound by fastening each sheet to the other *sideways*, and rolling the whole laterally from end to end, the last sheet serving as a cover to all the rest. The folded sheet, on the other hand, is bound by simply sewing or otherwise fastening the parts of the sheet to one another at the back crease or fold. And a number of folded sheets or of sections, as they are called, are bound by fastening each of them at the back to some common support, so that when all are sewn or otherwise fastened *at the back*, they may yet be free to open and shut *at the front*, or fore-edge.

The invention of the folded sheet thus gave rise to the inven-

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* Address delivered at the Royal Institution of Great Britain, February 2, 1894.

tion of modern binding, which in its essence is the union at the back of the folded sheets, which together constitute the folded book, or, as I might say, despite the latent contradiction, the folded volume.

Throughout the long period which has elapsed since the invention of the folded sheet—it is said to have been invented in the third century before Christ—binding must have undergone many and important changes. But of these changes few records remain. Speaking generally of the binding of the middle and later ages, we may say that at each successive epoch the form of the binding adapted itself to the state of literature at the time. When books were few and large and stationary, the binding was correspondingly large and bossy and heavy; and when books became numerous and lighter and portable, the binding adapted itself to the new conditions, and, dropping the oak boards, the brass fittings, clasps, bosses, and chains, became itself light and portable and beautiful. And thus wood and silk, and velvet and leather, iron and brass, and silver and gold, and precious stones, were all used by the artificers of the middle and earlier ages in the protection and embellishment of the world's written wealth. The invention of printing, however, and the multiplication of books, gave the victory to leather and to gold tooling, and with the invention of printing, binding passed into its modern phase, and became ultimately a craft apart, the craft of the bookbinder.

To the renown of bookbinding many countries and cities and patrons have contributed, as well as the artists and craftsmen whose work it has been. Singularly enough, the names of very few bookbinders are known, but it is well known that to Grolier and to France is mainly due the gold tooling which is still the chief means of making the bound book beautiful. This tooling, of obscure origin, was practiced first in Europe in Italy, but was soon after introduced into France by Grolier, and the French schools of the sixteenth and seventeenth centuries are still the great schools of design in that decorative method.

Deserving of mention or of allusion in this connection, even in the shortest account of bookbinding, are the innumerable crafts—crafts for the production of materials and crafts for the production of tools—upon which the binder's own craft depends. For this collaboration of crafts is a fact of capital importance and should always be borne in mind, that the solidarity of all industries may be understood and the dignity of each be appreciated.

It is to be regretted, however, that at this moment the craftsmen immediately concerned in making a book, the paper-maker, the printer, and the binder, are not in possession of ideas bearing and operative upon the book as a whole, and controlling their

several crafts to the one common end of the book beautiful, and the binder is in the unfortunate position of coming last, to inherit all, and be helpless under, the mistakes of his predecessors the paper-maker, printer, and publisher.

Modern binding may be divided into two main divisions: 1. Bindings for use. 2. Bindings for beauty's sake. I do not say that the divisions can be precisely defined or that the useful may not be beautiful, or that the beautiful may not be useful. I mean only that of a certain class the utility of the binding is the main characteristic, and that of a certain other class not the utility of the binding but the beauty of the decoration is the prominent and delightful feature. All bindings may be, and most bindings are, decorated in some form or other, but I would deprecate the decoration in gold of cloth or paper bindings; the material is too poor and the kind of binding is unsuitable for elaborate invention. Decoration should be reserved for cases in which a permanent pleasure is aimed at, and decoration in all its affluence exclusively for bindings of the best kind, and for books that are in themselves, apart from their apparel, beautiful and worthy of conspicuous honor.

The binding of a book, to come closer to our subject, is a series of processes too numerous to be entered upon in detail, in so short an account of bookbinding as the present, but the main operations are as follows:

1. The sheets are folded so that the headlines of each page shall, if possible, be at a uniform height throughout the book.

2. The sections are then sewn to cords, set and held at equal distances from one another in a frame, and at right angles to the sections.

3. The ends of the cords are frayed out and laced into and fastened to rectangular pieces of millboard (called boards), cut to the size of the sides of the book, which they protect.

4. The boards and back are then covered with leather or other suitable material, and the last and first sheets of the book (added to the book proper for the purpose) are pasted down upon the inside of the boards.

The book so treated is completely "forwarded," as it is called, and ready to pass into the hands of the "finisher" to be tooled or decorated, or "finished." The decoration in gold on the surface of a bound book is wrought out bit by bit by means of small engraved brass stamps called "tools." The steps of the process are shortly as follows:

1. The pattern is first worked out with the tools blackened in the smoke of a candle or lamp, upon a piece of paper cut to the exact size of the portion of the book to be decorated.

2. The piece of paper with the pattern upon it is then applied

to the surface to be decorated, and the pattern is reimpressed on the paper, and so through on to the surface of the book.

3. The paper is now removed, and the pattern on the book is reimpressed with hot tools to make the impression crisp and distinct.

4. At this stage a different process begins. The surface of the cover, with the pattern impressed upon it as described, is taken bit by bit and treated as follows:

1. First it is moistened with water or vinegar.

2. Then the pattern is penciled over with "glaire," which is a liquid composed of the white of an egg beaten up and drained off.

3. Then, when the glaire is dry, the surface is lightly touched with oil or grease to give a hold to the gold leaf next to be applied.

4. Then the gold leaf, cut to the size and shape of the portion of the cover to be operated on, is applied by a flat brush called a "tip," and pressed down by a pad of cotton-wool to reveal the pattern underneath.

5. Then, and finally, the pattern with the gold upon it is gone over again with the hot tools, and the gold is impressed into it. The rest of the gold is rubbed away with an oiled rag, and the pattern is now displayed permanently in gold and "finished."

The description is easy—how easy!—but the craft is difficult. Gold can not be persuaded to stick as a friend may be persuaded to stay; it must be *made* to stick—i. e., all the conditions upon which successful gold tooling depends must *in all cases* be observed, and there is the rub! What in each case—and the circumstances are never quite the same—*are* the conditions? How divine them? A little more or a little less makes so much difference. How dry may the leather be, or how damp must it be? How much glaire? How hot must the tools be? When is the moment to begin? Then how difficult it is correctly to manipulate the tools, to keep them even upon the leather! How difficult, finally, to keep the leather, throughout all the long and difficult operation, perfectly clean and the gold brilliant! What patience, what natural aptitude, what acquired skill, what fortitude! "The city sparkles like a grain of salt." "Shall I ever succeed?" the apprentice may well ask himself. "Shall I ever attain to such skill, to such consciousness of power, that I shall not even know *how* to fail?" In this difficulty, too, and in the effort and ambition to overcome it, lies a further difficulty, the snare of the art, the temptation of the finisher. He becomes engrossed in it—the finisher in mere finishing. He pursues it positively, and not in subordination to design. And he achieves victory at last, only to find that what he should have achieved, the thing beautiful, has escaped him. He can tool but he can not design; and he has so magnified execution that

when completely successful, when completely triumphant, he is then most conspicuously a failure. The tremulous outline of design—and design appeals to the imagination, to the inner eye of the soul as well as to the outer eye of sense—the tremulous outline of design has perished in the too great exactitude of his acomplished execution. Wholly to achieve victory, indeed, in the binder's craft, to forget no end in the prosecution of the means, to exaggerate no feature from long practice and perfect skill, to permit no craft of hand to overcome the judgment of the head, is, in bookbinding, as in all crafts, an exceedingly difficult task, and we have in the very development of a craft the cause of its ultimate decay. But what an education the prosecution of a craft is for the soul of a man! The silent matter, which is the craftsman's material, is wholly in his hands, it hears and makes no reproaches, but it never forgives and it has no mercy. Sunrise after sunrise lights the craftsman to his task, sunset after sunset leaves him to his regret. Shall the sun ever rise upon victory or set upon contentment? It is a great struggle. He only knows how great the struggle is, who knows what the aim of craft rising into the ideal is, and who tolerates, between him and it, no cloud of self-illusion, no splendor of popular praise to blind or to darken his gaze. And so through the work of his hand man may rise indeed to his soul's height. But the victory itself is withdrawn behind the veil. The world may not know it when it is achieved, and the artist himself may sometimes see it achieved, as he thinks, when to reach it he has yet to traverse the entire way of truth.

> "Sown in a wrinkle of the monstrous hill,
> The city—sparkles still, a grain of salt."

The great schools of design for the decoration of bound books are the great schools of France of the sixteenth and seventeenth centuries.

The first great school—the school of Grolier as it may be called—is characterized mainly by the simple motives of straightness and curvature. Straight and curved bands or straps and straight or curved lines are interwoven one with the other and distributed on a more or less simple or intricate but always symmetrical plan over the sides and back and sometimes the edges of a book.

The second great school—the school of the Eves—is characterized by the symmetrical distribution over the side of the cover of symmetrically drawn compartments or panels, and the union of them all into one organic whole by the intermediation of twisted or interwoven bands. This is its main and for its earlier years almost its only characteristic. But the school attained its maturity by the combination with it of an independent contem-

porary style, which consisted in the use of a number of branches, spreading from each corner of the cover toward the center, the unity of the whole being enhanced by a semis, simple or alternate, of some simple tools over the whole of the side. The combination was effected under the direction, if not by the hands, of the great binders Nicholas and Clovis Eve, and consisted in the enrichment of the interspaces of the first style by means of the sprays and branches of the second. When mature the school was characterized by compartments symmetrically distributed and connected, filled with dainty devices or with the severer tools of the Grolier pattern, and supported and enriched in the interspaces by foliated branches and sprays.

The third great school—the school of Le Gascon—and perhaps the last, was characterized by the combination with the geometrical framework of the preceding school of a new motive, borrowed, I think, from the contemporary lace, or perhaps filigree work, and used, ultimately, to fill in both the compartments or panels and the space between them. The motive is an exceedingly simple one, a small spiral of dots, but the close repetition of it has a singularly rich if somewhat bewildering effect. The school, however, in what specially characterized it, has dropped the tradition of form and is content with the glitter of gold. The repetition of the spiral is not always organic in its construction. The spirals are placed side by side, they do not grow the one out of the other. And I submit that all patterns, to be good, must be organic in the relation of their details and organic in the method of their development.

The great schools of design which I have thus attempted to characterize are historical, and they are closed. The future, as I have elsewhere had occasion to remark, is not, in my opinion, with them or their developments or repetition, however much the present may occupy itself with their corrected iteration.

Design is invention and development, and when development has reached a certain point the invention is exhausted and some new departure must be taken. No new departure, however, of any importance has taken place since the close of the great schools of France of the sixteenth and seventeenth centuries, and the decoration of bound books is still an open problem awaiting solution at the hands of genius.

But though the problem awaits solution the conditions of the problem may, I think, be stated shortly in general terms. In the first place, then, there must be in any design a scheme or framework of distribution. The area to be covered must be covered according to some symmetrical plan. In the second place, the scheme or framework of distribution must itself be covered by the orderly repetition and, if need be, modification and develop-

ment of some primary element of decoration. In the great French schools which I have attempted to describe, the *motifs* were primarily curved or straight bands or lines, and compartments composed of the same, the whole pattern of the first school becoming, in principle, the *motifs* of the second and third.

Before leaving this subject of design I may be permitted to prophesy that in the infinite inventions of Nature herself will, in the future as in the past, be found the suggestions of design, and that in seeking them there the craftsman artist will enter again into that vital communion with her which is the condition at once of his own happiness and of his own imaginative growth. But the prophecy must be accompanied by this caution—design can not, in my opinion, be taught. It is as distinctly a gift of imaginative genius as the power of poetical vision and expression. To the conditions of the problem, then, must be added the genius suitable for its solution.

I have now, in conclusion, to say what, in my opinion, the craft of the binder is, and in what relation it stands to the supreme art and craft of life itself.

All this universe of light and shade and sound, which at all moments surrounds us, and constitutes the supreme object of man's thoughts, his intranscendent inner and outer self, may be looked upon as itself a work of art in progress, and man's life through the ages as an attempt, ever renewed, to apprehend it in its entirety, and to reduce it to something appreciable by his imagination and his affections. This is not the moment to dwell at length upon this attempt, or to show how, with increasing knowledge of his environment, his previous conceptions of it have perished to give birth to higher and wider appreciations; but I may allege that, in my opinion, all the religions which have figured upon the stage of history, as well as all philosophical and scientific systems, are attempts at this reduction of the universe, and of man as a part of it, to an entirety harmonious within itself, and fit to be the dwelling place of the imaginative soul of mankind. They are attempts, and for some of us they have ceased to be adequate. For myself, I see only unbounded space and infinite time, and within those illimitables, a finite world obedient to law, unfolding to unknown ends; and though I can not grasp that world in its entirety, yet I can divine the amplitude of its rhythm, be sensitive to its adaptations and to the balance of its parts, and, in the spirit of the infinitely great, work at the infinitely little, and feel the two akin in their adjustments, balance, and rhythm.

It is in this intuition of the harmony of the universe that the ideal of the work of the hand resides. It is itself an adjustment, at once beautiful and serviceable. It is a dedication of man's

powers to an end not beyond man's reach; it develops invention and the imaginative faculties; it distracts the mind from the vexed question, never wholly to be put aside, of man's own ultimate destiny; it gives him rest; it gives him hope that, even as from the work of his own hands here there arise things of beauty and of use, so from his whole life's work there may arise in the "hereafter," which in some sense may be only another form of the "present," a something of even greater use and greater beauty still.

It is in this wise that I commend to you all the life of the workman, of the workman working in little in the spirit of the whole.

THE BEGINNINGS OF AGRICULTURE.

By M. LOUIS BOURDEAU.*

THE appropriation of the riches of the vegetable world is accomplished in two ways, according as our principal effort is to make use of the spontaneous products of wild plants or to multiply them by cultivation. The former, which constitutes the system of selection, reduces itself to mere taking possession, and, as it is executed by the most simple means, it can be practiced by all animals. The second method, which is applied to the production of resources that are needed, alone achieves a conquest and a durable empire. But it requires superior capacity and a degree of intelligence and reflection to which no other animal than man has risen. Cultivation might therefore serve, as does the use of fire, to mark the precise boundary where reason is separated from instinct and passes beyond it.

During an initial period of very long duration, man, destitute of knowledge and without power to act upon Nature, had to satisfy himself with utilizing the spontaneous products of plants, while he was incapable of adding to them by his industry. Like all plant-eating animals he subsisted on the resources of a hazardous collection. This sort of life demanded nothing more than an attentive search and the instinct to profit by happy finds. Existence was passed in wandering in quest of nutritious plants and gathering their fruits. The numerous families of monkeys and even some human tribes still live in this way.

So simple a method of exploitation is necessarily very restricted. Man did not in the beginning know the value of all the productions that abounded around him. First of all, he had to

* From his book, *Conquête du Monde Végétal* (Conquest of the Vegetable World). Félix Alcan, Paris, publisher.

learn to distinguish the useful plants among those which were not useful. It is not an easy task to pick out, in the three or four hundred thousand species of which the existing flora is composed, those most suitable for satisfying various wants—especially when we recollect that most of the uses we make of them, instead of being naturally indicated, are suggested by previous discoveries, and that there is no motive to impel one to seek in things a utility which is not suspected.

Primitive man was doubtless put in the way of making such discoveries by pressing necessities and the suggestion of chance. The terrible famines to which savages are exposed, which force them to eat the most insignificant berries, grasses, roots, and even the leaves of trees, caused them to learn by repeated trials the productions which could best afford them nourishment. Attention was fixed upon the most advantageous and least repulsive of them. Such experimentation, marked by disgusting and perilous features—for many poisonous plants proffer baits to greedy appetites by which they are sometimes caught—was accomplished at the instigation of hunger, with the assistance of instincts then more formal or better minded than now, comparable to those which guide animals so surely in the choice of their food. At a later date, nascent reason discovered various useful qualities in plants. Fortunate observations and trials followed by success showed what profit could be derived from products long neglected. The uses of wood assigned an increasing importance to it, first as a combustible, beginning with the discovery of fire, then as a substance that could be made serviceable in infinite ways. In time, men learned to separate, twist, spin, and weave bark and fibers, to color them in various shades, and to extract oil, wine, and sugar. Casual cures revealed the medicinal properties of simples. Every age saw an increase in the number of useful products which one could draw from plants. Even now, after the many investigations that have been pursued through thousands of ages, we are far from having made available all the resources which the vegetable world might furnish us; and its fertility holds in reserve for us many treasures of which we are still ignorant.

All the plants that have come into cultivation among us were first used wild, for their value had to be recognized before the thought of multiplying them could take shape. As long as they were naturally abundant enough to suffice for the necessities of sparse populations, no pains would be taken to propagate them. This phase of absolute uncultivation, the longest that the human species has traversed, appears to have continued from the origin of the race to the present geological period. Nothing, in fact, in the vestiges that have come down to us of that age reveals any signs of cultivated plants or of modes of cultivation; and such are

not found till the period of the station at Robenhausen, the most recent of the prehistoric ages. A similar condition has persisted among many peoples, not only savages reduced to the sorry resources of the animal searching, like the Hottentots, Bushmen, Fuegians, etc., but hunters, like a number of American tribes, Indians and Eskimos, and even pastoral people like the populations in Asia and Africa which live solely on the products of their flocks. Several peoples of Europe were found in a similar condition at no very ancient date. Tradition preserved among the Greeks and Romans the memory of a time when their ancestors, given over solely to pastoral industry, could neither till nor plant.* At the age represented by the kitchen middens and the oldest lake stations, the aborigines of Denmark and those of Switzerland were not aquainted with any sort of cultivation. A large part of England was, not less than twenty centuries ago, plunged in the same state of savagery. "The two most numerous peoples of Great Britain," says the abridger of Dio Cassius, "the Caledonians and the Meati, to whom all the others are related, live on uncultivated mountains or in desert plains, where they have neither cities nor cultivated lands. They subsist on milk, game, and wild fruits."† The narrative of the circumnavigation achieved by Other in the ninth century, on the shores of the Baltic, describes populations which lived by fishing, and makes no mention of agricultural products.‡ Even with peoples who have given agriculture its widest developments, a notable part of the resources is always borrowed from the products of the wild flora. We need only cite forest, woods, and pasture lands. Half of the territory of France has not yet been put under regular cultivation, and it is estimated that in the whole world the plants propagated by man do not occupy the tenth part of the surfaces which they might fructify.

Thus man has by the system of gathering become acquainted with and taken possession of the resources of which Nature offers him the gratuitous enjoyment. Although this mode of exploitation is anterior and appears strange to agricultural civilization, we should not fail to appreciate how necessary it was to the establishment of that condition. It has furnished valuable suggestions as to what the vegetable kingdom contained that was useful or capable of being made useful—that is, has indicated all the species which it was profitable to cultivate.

While the appropriation of the products of wild flora presented few other difficulties than those of trying and searching, it can

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* Varro, *De Re Rustica*, i, 2.

† Xiphilin, Abridgment of the Roman History of Dio Cassius.

‡ Periplus of Other, inserted in the introduction to Paul Orose's version by Alfred Le Grand.

procure only an extremely limited subsistence, because plants adapted to the wants of man were rare and scattered. Like the animals whose kind of life he continued, he first limited his demands to asking life and shelter from plants. A commensal of all the phytophagous species, he took his place as a parasite, not as a master, at the banquet of creation served without distinction to the multitude of the hungry. If he managed to subsist, it was with great difficulty, constantly a prey to hunger and in a perpetual uncertainty as to the future even in the midst of a temporary abundance, which was dissipated in his hands without his being able to make permanent provision.

To the phase of absolute uncultivation that occupied the first age of the human race succeeded a period of trials which was prolonged through the ages of savage hunting and pastoral barbarity. On rising from the state of Nature, men in quest of food would give more attention and care to the exploitation of the resources of the hunt, always available, than to that of vegetable production, which was limited to a short season. Wherever, as in North America, game was abundant over vast territories, the preying system could maintain itself independently. Where, on the other hand, game was rare and the extent of the territory small, as in Polynesia, the populations had early recourse to agricultural operations. Peoples who from being hunters became shepherds, obliged to wander from pasture to pasture with their flocks, were hardly able to devote themselves to agricultural experiments, which demanded sedentary customs. But when hunters, for lack of game, and shepherds, after droughts and epizoötics, became deprived of their customary resources, they were forced to call upon plants to supplement their subsistence. The getting of wild food was manifestly insufficient for populations which had multiplied in a relative abundance, and people were obliged, under pressure of necessity, to apply their ingenuity to the artificial propagation of useful plants to fill the measure of their wants. In fact, the more earnestly these plants were sought, the rarer they became. A certain number of species of great merit have thus disappeared from wild Nature, and are preserved only in cultivated varieties. The advantage of saving and increasing so precious types was understood at an early period, and man, exercising an intelligence of which no other animal had shown itself capable, learned to take good care of the plants which had proved most valuable to him. Doubtless fortunate accidents showed the way and were a revelation. Some seeds of fruits thrown down carelessly and springing up around the house suggested the thought of intentional plantings. The savage, who saw these young plants spring up and grow, watched over them, tried other experiments of reproduction and plantation—and the garden was formed, the begin-

ning of agriculture. Success was not difficult in regions where propitious conditions of soil and climate favored the propagation of plants of great productiveness. Observation and experiment next fixed the elements of a theory, limited at first to a few species, then extended and perfected by degrees. To reach these feeble beginnings by the rational methods of agriculture, a long series of attempts marked by more failures than successes had to be gone through. Gradually, however, the processes were improved; the resources increased, and the profits of vegetable production, so long surpassed by those of the hunt and of cattle-raising, at last prevailed over them; and this determined the adoption of a special kind of life, the consequences of which were destined to transform the condition of man.

Regarded as a whole, the cultivation of plants was a more complex and more arduous problem than the domestication of animals. To subject animals, it was enough to capture and hold them. They were then tamed as they became familiar, and afterward required nothing more than watching or protection. They could themselves provide for their wants, or make them known in a language easy to understand. They spontaneously sought their food and fled from danger. The mothers suckled and defended their little ones. Animal instinct thus saved the master of the herd much trouble. Plants, on the other hand, although their passive nature is apparently less rebellious to subjection than the undocile character and self-will of animals, really opposed more obstacles by the very fact of their lack of activity, on account of which they could not help and be sufficient for themselves. Constant watchfulness had to be exercised to see that their growth was accomplished regularly, for their needs never became evident till they were dying, and intelligent cares are necessary to prevent this or remedy it. Taking the propagation of plants under his charge, man had to choose a favorable soil for them, to break it up by toilsome labor, to put the seed in at the proper time, to stimulate their growth with manures, to furnish them water, warmth, and light, according to their needs. Their reproduction, in the wild state, was accomplished in the midst of innumerable risks, under the laws of the struggle for existence, and multiplicity of seeds could alone, in the face of a fearful loss, make sure the duration of species. In the hard and incessant struggle to which plants were given in the contest for ground and a place in the sun, the most precious, which were also usually weak and delicate, were liable to be smothered. To cause them to increase, man had to interfere in the conflict, to extirpate useless, vigorous, and aggressive species, and procure for those under his protection conditions of development. It was necessary, therefore, to clear, plow, and weed; to study the phenomena of vege-

table physiology, the qualities of different soils, the influence of exposure and climate, the course of the seasons, and the accidents of meteorology; to sow and to harvest at the most favorable moment, and then to store the products in such a way as to prolong the enjoyment of them. The establishment of agricultural industry thus exacted much more investigation, observation, and knowledge than that of pastoral industry; and further, instead of being limited, as in the domestication of animals, to a small number of selected species, agriculture had to extend its empire over thousands. This sort of life demanded, besides, more foresight, for it was necessary to work for results the profit of which was not gathered till after a long waiting. Finally, the profession of agriculture was much more toilsome than that of herdsman, and man, averse to hard work, recoiled long before the fatigue of so rude a task. He could not undertake it resolutely except during a phase of progress in which he had become more capable of reasoning, persistence, and effort. Agricultural civilization is therefore superior in every aspect to pastoral civilization by the extent of knowledge and foresight it implies, by the amount of labor it imposes, and by the quantity of wealth it creates. And when the two functions are in exercise at the same time, while the care of the herds is left to the most ignorant and weakest of the population—children, women, and old men—the agriculturists compose the most active, the most intelligent, and the most experienced part.

A progressive era of agricultural operations did not arrive till after both the hunting and the pastoral phases. On the one side, in fact, the destruction of wild animals must be sufficiently advanced to permit the cultivator to enjoy the reward of his labors, which too many spoilers would render of no avail. Agriculture would be hard to establish in a country where a pillaging and devastating fauna flourishes. In South Africa, for example, the plantations, exposed to the ravages of deer, birds, and insects, give little return. On the other hand, the co-operation of domestic animals was necessary, in order to plow large surfaces expeditiously as well as to fertilize by their manure the ground which repeated croppings would exhaust. This is the reason why, while we find among many peoples just issued from the savage state and destitute of cattle—Polynesians, Mexicans, Peruvians, etc.—interesting attempts at agriculture, they have not been able, in the absence of that resource, to arise themselves above a limited scale of gardening. The real agricultural system comes after the pastoral system.

But, this given, the other should arise from it in time, when the multiplication of herds in the natural pastures has reached a limit which can not be well exceeded. The least accident tending

to diminish that wealth will force the herdsmen to seek a supplement to their subsistence in temporary cultivations. Compelled to periodical migrations, they would adopt, in preference to fruit trees propagated from the wild state by sedentary hunters, a few plants of rapid vegetation, like the cereals, and particularly barley, which matures in a short time. Fields are thus occasionally sown around provisional encampments, an intermittent kind of agriculture, consistent with the care of the herds, as appears among Arabs of the Tell in Algeria. In especially favorable regions agriculture gained the preponderance, and the richness of the harvests, accruing more rapidly than that of the herds, attaching man at last to the ground, caused him to change his method of life.

Still, the first men who gave themselves up to regular consecutive work in the fields did not take their place without difficulty in a barbarous world. Antagonism and war would not fail to break out between the pastoral populations, jealous of their rights of way and of pasturage, and the agricultural populations, which, appropriating the ground put under cultivation by them, assumed to reserve the fruits to themselves. The contest between these rival interests and opposing customs occupied a period in the history of the ancient peoples. In the long run the agriculturists, more civilized, more numerous, and better united, at last carried the day, took possession of the most fertile lands, and drove the herdsmen into the steppes and the deserts, the only regions where their system could be perpetuated in its primitive purity. So, when pasturage and agriculture were developed in concert, a marked classification was worked out between the two professions; and while, in the beginning, such gods as Apollo, Mercury, and Pan, or such kings as those of the Vedic age in India and of the Homeric cycle in Greece, were not degraded by keeping herds, the shepherds lost in consideration as the agricultural system became more prevalent, and the business of attending to the cattle fell more and more to the farm servants.

The moment when man sought the chief support of his life in agriculture is one of the most important dates of history, and opened the decisive era of civilization. Till then, hunter or fisherman, he lived chiefly upon his catches, free or domesticated, and, superior to carnivorous species, he differed from them only in having a more intelligent method of hunting. When he became an agriculturist, he rose above all the animals by a manner of living without analogy among them. He made the land his domain, cut down the forests, plowed the ground, and propagated by industry the plants useful for his wants. From that time he had at his disposal incomparably vaster resources than he could draw from animals. His comfort, henceforth assured, depended

on himself only, and populations increased rapidly. Under the influence of these new conditions all the elements of civilization were developed and advanced. Varied industries were constituted to give value to the productions of the earth, habits were regulated, and milder religions substituted for the bloody sacrifices of the pastoral phase peaceful offerings of wheat, meal, oil, and wine.

This memorable event of the adoption of the agricultural system by the first pioneer groups probably dated from the later prehistoric times, and could in no case have been anterior to the subjection of the auxiliary animals during the pastoral stage. The dawn of history shows us large empires, already flourishing, from three to four thousand years before the Christian era—Chaldea, Egypt, and China—enriched and civilized by agriculture. The point of beginning should undoubtedly be thrown some thousands of years still further back. Probably also the mythological traditions relative to the origin of husbandry, in which honor is rendered to deified personages, such as Ceres, Triptolemus, Minerva, Bacchus, Osiris, Noah, etc., refer not to the primary institution, which was probably effected by degrees and slowly, but to the extension of the processes, which may sometimes have been made in a very short time and would all the more strike the imagination of the peoples. The agricultural system once fixed, the initiative of a leading innovator might introduce it by imitation into a country still barbarous, rapidly change the aspect of a district still uncultivated, and bring it, in less than a generation, to the point where territories that had already been transformed by cultivation had arrived after centuries of efforts. Those were undoubtedly benefits of this kind of which myths have transmitted the reminiscence to us. During these ages of ancient barbarity the fertility of the soils, suddenly revealed by practical sages, would appear miraculous to tribes that were acquainted only with the aridity of the steppes. The prodigy of making wheat and the vine grow where only grass and rushes had been would seem to partake of the divine, and it is conceivable that altars should have been erected to those who accomplished it. In the Oriental mythologies the conquest and distribution of domestic animals did not give rise to such legends; whence we may suppose that those achievements dated from an anterior cycle when religious conceptions, more closely related to primitive fetichism, induced the adoration of the animals themselves instead of those who subdued or introduced them, and of whom no recollection survived.

It is easier to indicate the countries in which the evolution occurred in which the pastoral system was supplanted by the agricultural. As our most valuable plants originated in regions now well determined by botanical geography, we thus know the area

in which their cultivation was established as the center whence it radiated to different quarters. By this induction we are authorized to affirm that agriculture was first established in that part of the ancient world which also furnished the most useful species of animals for domestication. Asia has, in fact, contributed most of our fruit trees, cereals, and economical and industrial plants. The fertile valleys of the Euphrates, the Nile, the Ganges, and the Yang-tse-kiang were acquired to agricultural civilization very early. While we are not able to say which is entitled to priority, we can distinguish two principal centers of cultivation in the ancient continent—one in the southwest of Asia (Mesopotamia and Egypt), and the other in the east (China, India, and Indo-China). The former, which seems to have been the more important, propagated barley, wheat, the vine, flax, etc. The second acquired rice, tea, sugar cane, the mulberry, cotton, etc. A third center, more tardily constituted in intertropical America, gave us Indian corn, the potato, tobacco, etc. The north of Asia, Europe, South America, the United States, and Australia have furnished very little.

Without regarding the negroes and the American populations, which, continuing nearly in their original savagery, and having not even risen to the pastoral system, could give only an extremely limited aid to the establishment of agriculture, the credit of having introduced high cultivation can be disputed only by the three races which shared the dominion of the ancient continent. The claims of the Mongolian race are distinct enough in consequence of its long isolation. Some of its peoples have preserved their nomadic customs. Only China and its annexes adopted the new method of living. Yet, although agriculture has been long honored there, its general advance has been less evident than elsewhere, and the Middle Kingdom has hardly got beyond the practice of a highly perfected gardening. The claim of the Semitic race is based upon the record of the two ancient empires, Chaldea and Egypt, which were truly initiators. Yet, although it seems to have given the first example, it had not the honor of making the most decisive advances. Both pastors and cultivators, the Semites perhaps made the most material contribution to the passage from the former kind of life to the other. The pre-eminent agricultural race was that of the Aryans, which only exceptionally ever led a pure pastoral existence, and the name of which is associated with a root from which is derived also the word *arare*, to plow—as if the Aryans, to distinguish themselves from the nomads who surrounded them, desired to give themselves the characteristic appellation of *plowmen*.* In Europe, and under

* Max Müller, Science of Language.

less favorable conditions of fertility, their descendants have carried agricultural industry to its most advanced point, have constituted the theory of rational cultivation, and have most largely developed the system of civilization which is the consequence of it.

The first people who adopted the agricultural system possessed only a few species of plants borrowed from the local or neighboring flora. Each region, apart from the others, was poor; only the world was rich. To compose the treasure of our agriculture, it was therefore necessary to collect in each country the best products of all the others. Such sharing in common was for a long time impracticable for want of relations between the ethnic groups, which were separated by geographical obstacles or impassable distances. Gradually profitable exchanges distributed the plants from their native regions into the zones which were suited to receive them. From the time when special centers of cultivation were established, the richness of this fund has gone on increasing. The migrations of peoples, their military expeditions, their conquests, the foundations of distant colonies, commercial and political relations, and often the intelligent curiosity of travelers gave opportunities for inestimable gains. The Egyptians sought for new plants. Queen Hatasu sent a squadron of five ships to the ports of the country of Punt, to bring from there fragrant trees, which she planted in her gardens at Thebes. Thothmes III had represented in one of the chapels of the Temple of Amun at Karnak the various species of plants he had collected during his campaigns in Syria and on the Upper Nile. We may also cite the case of the embassy of Chang-Kien, who, sent in the second century by the Emperar Won Ti into Bactriana, brought back a number of plants with which he enriched the agriculture of the Celestial Empire.* At successive dates, all the agricultural peoples have made their contributions to the common stock and have drawn largely from a constantly increasing patrimony.

The Indo-European race, with its taste for travel and its ambition for expansion, has especially contributed to the dissemination of useful plants. Originating in the center of Asia, it in the very beginning borrowed from its elder sisters the resources, acquired by them, of an agriculture which was destined to become cosmopolitan. The most ancient Aryan migrations carried into India and into Europe the precious seeds which the race had collected near its cradle. The Phœnicians, Greeks, and the Romans afterward propagated on the shores of the Mediterranean a choice of fruit trees, vegetables, and industrial plants selected from three continents: the vine, the olive, the almond, the walnut, the chest-

* The Pen-ts-'ao mentions the bean, the pea, lucerne, sesame, saffron, and the walnut.

nut, the plum, the apricot, the peach, the cherry, etc. In extending their domination from one extremity of the ancient world to the other, the Arabs still found something to glean, and the Crusaders took numerous loans from them. Europe then acquired rice, sugar cane, and the orange. Finally, since the great expeditions of the Renaissance, the flora of the entire world has been put under contribution. The Romans caused trees loaded with fruit to figure in their triumphs, in testimony, Pliny says, of a victory which had been gained over Nature not less than over men. Thus, wherever civilization established itself it sought, in order to make itself welcome and its presence a blessing, to lavish upon the new lands the gains which it had accumulated in its former cultivations. Like the gods of other days, when they descended among men, it appeared with its hands full of precious gifts. This propagation of useful plants is of itself so great a benefit that it compensates, and more, for all the evil that civilization has been accused of spreading.

During the course of the subjection of the vegetable world to our use, the conquest has followed an order upon which the documents of the past do not always cast a sufficient light, but of which it is possible to restore the stages by means of a logical induction, while bearing in mind the urgency of the needs, the difficulties of cultivation, and the complexity of the uses. The first plants which man interested himself in propagating were those which would assure his subsistence, for the demands of hunger are the most imperious. Then came economical and medicinal plants. The industrial species usually belong to a later stage. Ornamental and fanciful species were a late gain and the luxury of an already rich civilization.

Suess, in his book, The Face of the Earth, and Neumayr, accepting the Chaldean story of the flood as the original version of the Mosaic account, held that it was a local event in the plains of the Euphrates and Tigris, and that view has prevailed extensively. Richard Hennig, however, discussing the subject in the German Weekly Magazine of Science, argues in favor of the independent origins of the flood stories found among so many peoples, and associates it with some of the striking phenomena of the Ice age which indicate a general increase of rainfall and lowering of temperature during the Quaternary period. Isolated lands —Egypt, for instance—far from these influences, remained free from interruption. The accounts in the German Saga would apply well as descriptions of such a period.

Of the people of Montenegro, Mr. W. H. Cozens-Hardy says that every man, even the poorest, has the bearing and dignity of a gentleman. Education is universal and compulsory on all children over seven. Theft is unknown, and drunkenness unheard of. Women are universally respected; a woman goes in safety where no man dares.

SKETCH OF THOMAS NUTTALL.

IT has often happened that a young man who has begun life as a printer has afterward attained to distinction in some more intellectual pursuit. So it was with Benjamin Franklin and so with him whose story is to be told here. Whether this is due to the information which the young printer obtains from the matter constantly passing through his hands, or whether it is because the most intellectual of the young men who learn a mechanical trade take to printing, it would be difficult to say. The fact only need be noted here.

THOMAS NUTTALL was born in 1786, in the market town of Settle, in the West Riding of Yorkshire, England. His parents were probably in humble circumstances, for at an early age he was apprenticed to the printer's trade, either in his native town or in Liverpool, where he had an uncle engaged in this business. He worked as a journeyman for this uncle several years; then, having had a disagreement with him, young Nuttall went to seek employment in London. He was not fortunate in the metropolis, and sometimes went to bed without knowing where he would get his breakfast the next morning.

When twenty-two years of age he came to America, landing in Philadelphia. He must have devoted a large part of his spare moments to study during his early life, for he has been described on his arrival in this country as a well-informed young man, knowing the history of his country and somewhat familiar with some branches of natural history and even with Latin and Greek. A testimony to his early studious habits came to notice sixteen years later. It is thus recorded in the biographical notice of Nuttall, read by Elias Durand before the American Philosophical Society, which has been taken as the basis of this article:

"When, in 1824, Prof. Torrey was preparing for publication his Flora of the Northern and Middle States, which he dedicated to his friend Thomas Nuttall, with high compliments, the printer who was engaged upon it asked the professor who was that Nuttall so frequently referred to in his work, adding that he had once worked with a printer of that name, who spent the greatest part of his time in reading books, and he would not be surprised if he were the same man. Prof. Torrey rejoined that 'his surmise was correct; the printer of former times had proved a most arduous laborer in the field of science, and was now a distinguished botanist and an officer of one of the first scientific institutions of the country.'"

That Nuttall knew nothing of botany when he landed in the United States is shown by an anecdote that he used to tell of him-

self. Taking a walk in the outskirts of Philadelphia the morning after his arrival, he noticed a common greenbrier (*Smilax rotundifolia*). "Egad!" said he to himself, "there is a passion-flower"; and he plucked some branches of it, which he brought home for inquiry. His fellow-boarders could not satisfy him, but referred him to a certain Prof. Barton, a great botanist, whose residence was near. With his treasured branch in his hand, Nuttall called at once upon Prof. Benjamin S. Barton, who received him courteously and pointed out the difference between the genera *Smilax* and *Passiflora*. Then, perceiving the intelligence of the young man, Prof. Barton went on to tell him some of the general principles of botany and how much pleasure could be derived from its pursuit. This conversation made Nuttall a botanist, and Barton became his friend and patron. It was then early spring, and throughout the season of flowers he took frequent rambles over the neighboring fields, eagerly gathering specimens, which he brought to Barton, studying them with him and preparing them for the herbarium. Soon he began to extend his excursions, going first down into the lower part of the peninsula between the Delaware and Chesapeake Bays, and later to the coasts of Virginia and North Carolina. When occupied with his favorite pursuit, serious discomfort could not distract him. At one time, while collecting in the southern swamps, his face and hands became covered with mosquito bites, so that when he approached a human habitation the people of the house would not at first admit him, believing that he had the smallpox, and it was with great difficulty that he convinced them of the contrary.

Returning from this trip, he made the acquaintance of Mr. John Bradbury, a Scotch naturalist, who had come to America to collect objects of natural history in the interior. Nuttall eagerly offered to accompany Bradbury, and his proposition was accepted. Proceeding to St. Louis, they set out from that city on the last day of December, 1809, crossed the Kansas and Platte Rivers, passed through the Mandan villages, where Lewis and Clarke had spent the winter of 1804–'05, and ascended the Missouri River still higher, returning after an experience full of the greatest fatigues and dangers. They were pursued and robbed by the Indians, and Bradbury, who was captured by them, only saved himself from being killed by taking his watch to pieces and distributing the works among them. Nuttall, overcome by fatigue and hunger in the wilderness, laid himself down to die, but was found by a friendly Indian, who took him in his canoe down the Missouri to the first settlement of white men. In spite of these misadventures, he was able to bring with him on his return, in the beginning of 1811, ample treasures of seeds, plants, minerals, and other natural objects.

For the next eight years he remained in Philadelphia, during the winter months studying the collections made by him in summer excursions to various parts of the country east of the Mississippi, from the Great Lakes to Florida. Being absorbed in his studies and naturally reserved, Nuttall's social intercourse was limited. The families of the botanists and horticulturists of the time in Philadelphia—Prof. Barton, Zaccheus Collins, Reuben Haines, McMahon, from whom he named his genus *Mahonia*, William Bartram, and Colonel Carr—were almost his only acquaintances. To these he made visits, often of several days, from time to time. In Colonel Carr's house a room was expressly reserved for him. During this period he prepared also the description for his Genera of the North American Plants. Upon this work, which appeared in 1818, the reputation of Mr. Nuttall as a botanist principally rests. Prof. Torrey, in the preface to his Flora, declared that it had "contributed more than any other work to the advance of the accurate knowledge of the plants of this country." Nuttall turned his early trade to account by setting the type for the greater part of his book.

In 1817 Mr. Nuttall, already a Fellow of the Linnæan Society of London, was elected a member of the American Philosophical Society at the same meeting with Say and Schweinitz, and a corresponding member of the Academy of Natural Sciences of Philadelphia. He began to publish essays in the journal of the Academy, among the earliest being a description of *Collinsia*, a new genus of plants, named in honor of his friend and patron Z. Collins.

Nuttall had long desired to visit the Arkansas country, and soon after his American Plants was published Messrs. Correa de Serra, Z. Collins, William Maclure, and John Vaughan procured him the means of performing this long journey. Starting from Philadelphia on October 2, 1818, he reached the mouth of the Arkansas River about the middle of January and Fort Bellepoint on April 24th. Thence he made expeditions in several directions, returning with abundant collections. He was on one of these trips in the middle of August, when, exhausted by long and difficult marches, made under the rays of a burning sun and in constant dread of the Indians, having suffered much from thirst, insufficient food, and exposure to the night dews, he was seized with a violent fever among the Osage tribe. The Indians robbed him of his effects and even threatened his life, but he finally reached the garrison at Bellepoint, where he remained sick until the middle of October. He made one more trip and then set out for home, reaching New Orleans February 18, 1820. He had then in sixteen months made a journey of more than five thousand miles, mainly over a country never visited before by scientific explorers, and still in the undisputed possession of the Indians.

Getting back to Philadelphia early in the spring of 1820, he immediately set about arranging his Arkansas collections and preparing his Journey into the Interior of Arkansas in 1818 and 1819, which he published in the following year. In the course of the years 1820 to 1822 he contributed several memoirs to the Journal of the Academy of Natural Science, among them being one On the Serpentine Rocks of Hoboken and the Minerals which they Contain, for he was giving some attention to mineralogy at this time. He also lectured on botany to classes of young men. His lecturing was not remarkable for eloquence, but he always communicated to his pupils something of his own passion for his favorite science.

At the end of 1822 Mr. Nuttall was called to Harvard College. The fund of the college for a professorship of natural history not being sufficient to support a professor, he was appointed merely Curator of the Botanic Garden, and but light duties of instruction were assigned to him. In consequence the greater part of his time was devoted to the culture of rare plants and to his own studies, in which mineralogy and ornithology were included. In Cambridge, as in Philadelphia, he led a retired life.

In editing the Letters of Asa Gray Mrs. Gray remarks: "The garden was laid out by Dr. Peck in 1808, and the house built for him was finished in 1810. Mr. Nuttall, the botanist and ornithologist, who boarded in it while giving instruction in botany, left some curious traces behind him. He was very shy of intercourse with his fellows, and having for his study the southeast room, and the one above for his bedroom, put in a trapdoor in the floor of an upper connecting closet, and so by a ladder could pass between his rooms without the chance of being met in the passage or on the stairs. A flap hinged and buttoned in the door between the lower closet and the kitchen allowed his meals to be set in on a tray without the chance of his being seen. A window he cut down into an outer door, and with a small gate in the board fence surrounding the garden, of which he alone had the key, he could pass in and out safe from encountering any human being."

Aware that he was doing little for science, Mr. Nuttall became dissatisfied with his position at Cambridge; he used to say that he was only vegetating, like his own plants. Congenial occupation was furnished him for a time by the suggestion of Mr. James Brown, who was probably his only intimate friend in Cambridge, that he write a book on ornithology. He had given more or less attention to this science during almost the whole of his residence in America, and readily adopted the suggestion. He set to work with great zeal, and in 1832 produced his Manual of the Ornithology of the United States and Canada. It was published in

two volumes of about six hundred pages each and illustrated with excellent woodcuts. In the course of his residence at Cambridge he contributed papers to the various scientific periodicals of the time, and issued a little book entitled An Introduction to Systematic and Physiological Botany.

About the beginning of 1833 Mr. Nuttall went to Philadelphia with a collection of plants gathered by Captain Wyeth during a journey overland to the Pacific Ocean. Captain Wyeth was soon to start on a second expedition, to establish posts for the Columbia Fishing and Trading Company, and Nuttall wished to accompany him. Not being able to obtain a sufficiently long leave of absence from Cambridge, he resigned his position at the college and spent the interval before the departure of the expedition in Philadelphia studying the collection already referred to and his own Arkansas plants.

Mr. Nuttall and Mr. John K. Townsend, a young naturalist, sent out jointly by the American Philosophical Society and the Academy of Natural Sciences, joined Captain Wyeth's party at Independence, Mo., from which place the start was made April 28, 1834. The details of the journey are given in Townsend's Narrative of a Journey across the Rocky Mountains to the Columbia River, etc. On September 3d they came to the Columbia, and, descending it, reached Fort Vancouver. Here the two naturalists remained for the rest of the autumn to explore the surrounding region. Then desiring to pass the winter months where inclemency of the season would not interfere with their pursuits, they took passage on a Boston brig for the Sandwich Islands, where they arrived January 5, 1835.

Here for the first time Mr. Nuttall enjoyed the beauties of a tropical vegetation. He remained two months collecting plants and sea shells on the several islands, and then, separating from his companion, sailed for California. He spent a great part of the spring and summer on the Pacific coast, then returned to the Sandwich Islands, where he embarked on a Boston vessel to come home by way of Cape Horn. It happened to be the vessel on which Mr. Dana was serving his two years before the mast, and the latter relates in his book that when rounding Cape Horn Nuttall's passion for flowers was aroused by the near view of land. He entreated the captain to put him ashore, if only for a few hours, that he might become acquainted with the vegetation of this dreary spot, although the wind was blowing furiously and the ship was surrounded with icebergs. When his persistent requests were sternly refused he was much disappointed and displeased, being unable to comprehend such indifference to the cause of science.

He arrived in October, 1835, and again took up his abode in

Philadelphia to work up the rich treasures gathered on his long journey. For several years he and Dr. Pickering worked harmoniously together at the Academy of Natural Sciences—the former on his own collections, the latter on the Schweinitz herbarium. Two important memoirs based upon the fruits of the trip across the continent were published about 1840 in the Transactions of the American Philosophical Society. Conchology was a new subject of study to Nuttall, and he became much absorbed in it. He did not trouble himself much about his meals when at work, and Dr. Pickering would often return after an hour's absence from the Academy hall in the middle of the day and find him stooping over a case of shells in the same place and position as when he left him.

Nuttall was a remarkable-looking man. His head was very large, bald, and bore the signs of a vigorous intellect; his forehead was expansive, but his features small, and his gray eyes looked out from under fleshy brows. His complexion was fair, and sometimes very pale from close application to study and lack of exercise. He was above medium height, his person stout, with a slight stoop, and his walk peculiar and mincing, resembling that of an Indian.

He was naturally shy and reserved, but, if silent and perhaps morose in the presence of those toward whom he felt no attraction, yet with congenial companions he was communicative and agreeable. It will readily be surmised that his devotion to science frequently led him into actions that were strangely at variance with the circumstances of the moment. In one of his solitary digressions in the wilderness he got lost. The party he was with resumed its march, sending out some friendly Indians to find him and bring him to rejoin it. The Indians performed their duty faithfully. Looking upon him, however, as a great medicine man, they were afraid to come close to him, so they surrounded him, keeping at a respectful distance. Nuttall soon became aware that he was watched by savages, and, not knowing whether they were friends or foes, became intensely alarmed. From what he had already experienced at their hands he had the utmost horror of Indians. Therefore hiding himself, and taking advantage of every ravine, every tree and bush, he succeeded in regaining the track of the caravan, which he followed for three days without food or sleep, when, to his infinite delight, he overtook it and was relieved from his anxieties.

On another occasion he was rambling in the vicinity of the camp when a band of Indians, apparently hostile, made its appearance. The alarm was immediately given, with orders to prepare for an expected attack. Nuttall was nowhere to be seen, and a friend ran in search of him. It was not long before he per-

ceived the naturalist at some distance, quietly examining a specimen. He hailed him with signs to return quickly. "We are going to have a brush with the Indians," said his friend; "is your gun in good order?" Alas! the gun had been freely used to uproot plants, and was filled with earth to the muzzle. Had Nuttall fired it in this condition it would inevitably have burst in his hands and killed or severely wounded him.

On his journey to the Pacific the caravan separated into two parties to cross the Rocky Mountains by different routes. One of the parties had the good fortune to meet with plenty of buffalo cows, upon whose meat they became fat. The other, to which Nuttall belonged, suffered much from fatigue, and found scarcely anything to eat except a few lean grizzly bears. When the parties reunited, Nuttall had lost so much flesh that his old companions could scarcely recognize him. Upon one of these expressing his surprise at the great change in his appearance, he heaved a sigh of inanition and retorted, "Yes, indeed, you would have been just as thin as myself if, like me, you had lived for two weeks upon old Ephraim (grizzly bear), and on short allowance of that too!"

At Christmas, 1841, Nuttall returned to England, where he resided for the remaining seventeen years of his life. An uncle who had prospered in business, having no family of his own, bequeathed to him an estate called Nutgrove, in the neighborhood of Liverpool. A condition attached to the bequest was that Nuttall should reside in England at least nine months of the year for the rest of his life. He had been thirty-four years in the United States and become much attached to this country, so that, although he had visited England in 1811 and 1822, returning to reside permanently in the land of his birth seemed to him like going into exile. He therefore hesitated for some time to accept the inheritance, but consideration for his sisters and their families finally induced him to take it. Becoming a British landed proprietor did not make Mr. Nuttall wealthy. The Nutgrove estate was encumbered with annuities, besides which there was a heavy income tax to pay. Dr. Pickering and other American friends who visited him found him living in the fashion of a plain farmer, working and eating with his men like one of them. But his interest in botany was not allowed to die out. He made use of the opportunity which the possession of ample grounds afforded for the cultivation of rare plants, especially rhododendrons, which his nephew, Mr. Thomas J. Booth, brought him from the mountains of Assam and Butan. Various new species of these were described by him in British scientific journals.

Shortly before leaving the United States Nuttall was induced to write a supplement to Michaux's Sylva in three volumes. In the beautifully written preface to the work his own wanderings

are vividly sketched. Owing to various delays the edition was not issued till 1846.

Nuttall returned only once to America. As he could not be absent more than three months in any one year, he took the last three months of 1847 and the first three of 1848—not a very desirable season for a botanist's outing. Nevertheless, he managed to do some congenial work. He studied at the Philadelphia Academy the plants brought by Dr. William Gamble from the Rocky Mountains and Upper California, and prepared a paper on them which was published in the journal of the Academy.

His death occurred on September 10, 1859. In his eagerness to open a case of plants received shortly before from Mr. Booth he overstrained himself, and from that time steadily declined until he died. Through his love of Nature, joined with untiring industry and great firmness of purpose, he had raised himself from the condition of an unknown artisan to the foremost rank of American men of science. No student begins upon the study of systematic botany without being struck by the frequency with which his name is met. His friends and colleagues, Profs. Torrey and Gray, have testified to their appreciation by attaching his name to a beautiful genus of the *Rosaceæ*. Elias Durand said of him immediately after his death: "No other explorer of the botany of North America has personally made more discoveries; no writer on American plants, except perhaps Prof. Asa Gray, has described more new genera and species."

Among the Kayans of Borneo, according to Mr. C. Hose, when a child is born, the father and mother sink their own identity and adopt the name of their offspring. Supposing a man named Jau becomes the parent of a son to whom he gives the name of Lahing, the former would no longer be called Jau, but Taman Lahing, father of Lahing. If his child were to die, he would be called Ozong Lahing, or Ozong Jau; if his wife dies, he adds the prefix Aban (widower) to his name; if a brother or sister, Boi, and he is called Boi Lahing. Should he attain the position of being a grandfather, he becomes Laki, adding thereto the name of his grandchild; so if the latter is given the name of Ngipa, the grandfather is no longer called Taman Lahing, or by any other name but Laki Ngipa. A widow is called Ballo.

In considering temperature as a factor in the distribution of marine animals, Dr. Otto Maas, of Munich, said, in the British Association, that the great ocean currents were primary elements in limiting the distribution of free-swimming forms, very few species being found both north and south of them. The influence which had been ascribed to pressure might often be more correctly attributed to change of temperature, as in the case of deep-sea animals which died on being brought to the surface in the Atlantic but not in the Mediterranean. In conclusion, attention was called to the corals and the geryonid jellyfish as illustrative of the principles laid down, both having a similar distribution, though the former are fixed, the latter free swimming.

CORRESPONDENCE.

SLEEP AND DREAMS.

Editor Popular Science Monthly:

IN reading Dr. Wurtz's article on the Chemistry of Sleep, in the issue of December, I observe that he considers dreams to be an essential element of "normal sleep." "Sleep so deep as to be dreamless is probably not of the most natural kind. . . . No one would claim that natural dreams are symptomatic of morbid conditions," etc. And speaking of the sleep produced by the administration of nitrous oxide with oxygen, he says, "But the lethargy thus produced is dreamless, and *therefore not normal sleep.*" The Italics are mine.

I think the experience of the larger number of people in average health is against this proposition; for dreaming is only occasional with them, and is usually considered in the light of a disturbance and as detracting to that extent from the rest and refreshment of the season. And the experience of people who frequently and even "regularly" dream is against it likewise; for it is certain that an ordinary dream occupies usually only a small portion of the time devoted to and spent in sleep, and that under ordinary circumstances the duration of dreamless sleep during the night, even with habitual dreamers, is many times greater than the duration of their dreams.

Then if, as all physiologists are agreed, sleep is in general terms a condition of rest and recuperation, especially of and to the "apparatus of relation"—the brain, the organs of sense, the voluntary muscles and their associated nervous system—it follows that *it ought to be* dreamless to be entirely effective (and normal). For observe that inasmuch as, so far as our experience teaches us, there is with us no consciousness without change of condition in *some* of the matter of our bodies, which means *metabolism*, which means destruction of tissue, therefore a given amount of consciousness in dreams (as in waking)—cerebral vision, audition, emotion, or what not—is at the cost of a certain amount of tissue change, and results in the accumulation in the blood of so much effete matter and gives to the excretory organs so much extra work to do. Both experience and theory are thus shown to be against his position.

I refrain from criticising in detail his "definition, or rather description, of the conditions we find in sleep," of which, however, it may be said that it will not bear the scrutiny either of logic or fact. Nevertheless, it does not follow that his article is uninstructive or valueless, for we often find that the errors in a conscientiously thought-out thesis lead to a more thorough understanding of the subject than would have been attained had all the propositions been demonstratively true.

GEORGE PYBURN, M. D.

SACRAMENTO, CAL., *December* 20, 1894.

DO BIRDS CHANGE THEIR FOOD?

Editor Popular Science Monthly:

IN a review of M. Frédéric Houssay's book on Thrifty Birds, occurring in your October number, page 856, it is said of the California woodpecker that, "though an insect-eater, it stores away for its winter supply food of an entirely different character, nor so subject to decay. It collects acorns for which it hollows small holes in a tree—a hole for an acorn—into which the acorn is exactly fitted, ready to be split by the strong beak of its owner," etc.

Now we have the same habit among various woodpeckers here, but the cause is not ascribed to the bird changing its diet, for examination of the acorns shows each one to be infested with a worm or larva which is rapidly fattening. It is this and not the meat of the nut which the woodpecker desires. It would seem, then, that M. Houssay is open to criticism in what he says about "change of diet." F. L. WASHBURN.

CORVALLIS, ORE., *September* 30, 1894.

STUDIES OF CHILDHOOD.

Editor Popular Science Monthly:

I WAS much interested in the article entitled Studies of Childhood, in the January number, but it seems to me that one, at least, of the writer's deductions is too serious. In discussing the child's idea of personal identity, he recalls instances in which the child's past self is remembered as of the opposite sex. I myself have noticed this peculiarity a number of times. Now, in each of my examples, as in those cited by the author, it is a boy who refers to himself as having been a little girl. Might not the simple fact that during infancy dresses are worn explain this delusion?

HARRIET HEYL CARY.

CHICAGO, *December* 23, 1894.

EDITOR'S TABLE.

SOCIOLOGY IN THE UNIVERSITIES.

THERE was nothing commonplace about the title that first confronted the readers of the initial number of The Popular Science Monthly in May, 1872. The Study of Sociology: Our Need of It, had the flavor of that happy and legitimate audacity that makes things "go." For nobody knew what "sociology" was. Only a few curious readers of Comte, and subscribers to Mr. Spencer's Synthetic Philosophy, had ever met with the word. It is familiar enough now; and if the repetition of phrases meant always the assimilation of ideas, we might expect the coming generation to think of society as rationally as it will think of the solar system and the descent of man. "Sociology" confronts us in the morning newspaper; it is the favorite fad of philanthropic institutions; it is discussed in ministers' meetings, and it pleasantly stimulates the scientific ganglia of ladies' clubs.

The popular history of sociology in these twenty-three years has therefore been interesting and instructive. To Mr. Spencer and his followers the word has always meant a strictly scientific description and explanation of society as it is and as it has been. The business of the sociologist, as Mr. Spencer understands it, is to interpret the life and organization of society in terms of natural causation and evolution; not to abolish evil for dissatisfied people, nor to invent new moral worlds for gullible people, nor to fit out reformers with a brand-new set of rules of thumb. But it was inevitable that as soon as the serious scientific study of society was talked about the uninstructed and incompetent should try their hands at the task; and a curious mess they have made of it. They have seized upon the word sociology and made it do service in aid of every crazy enterprise and sentimental crusade that all the cranks in Christendom have ever thought of. To cap the climax, the theologians of the Christian socialist variety, and certain so-called "economists" who enjoy airing their disbelief in pretty much everything that used to be called political economy, have put their heads together and invented something that they call "Christian sociology," a last ridiculous manifesto in the warfare of obscurantism against science. Unable longer to sell text-books of six day geology, these estimable persons will see to it that the law of population and the formula of marginal utility are put on a safe Christian basis!

Meanwhile, however, a real and great progress has been made in the constructive development of scientific sociology, and, what is not less important, in teaching it. But it has been made so quietly that the general scientific public is scarcely aware of what has been accomplished. In European universities of the first class sociology is to-day firmly established as a recognized subject for degree work, and it is taught by extremely able men. De Greef at Brussels, Gumplowicz at Grāz, Letourneau at Paris, Durkheim at Bordeaux, and Simmel at Berlin are professors who combine scientific training with a philosophical grasp of their subject. In this country Prof. Sumner began using Spencer's Study of Sociology as a text-book at Yale soon after its publication. Since then courses in sociology have rapidly multiplied in our colleges. The new University of Chicago recognized the claims of such studies by putting Prof. Small, whose teaching has been based in a good degree on the views put forth in Ward's Dynamic Sociology, in charge of a well-equipped department of social science. Columbia College last year

gave a new impetus to the movement by founding the first American university chair of sociology to be officially called by that name, and by calling to it Prof. Giddings, who holds that social ethics can never teach us what social relations ought to be until sociology has analyzed and classified them as they are; discovered how, through an evolutionary process, they came to be as they are; and explained in terms of natural causation why they are what they are, and not in all respects what we might wish them to be.

For university purposes it is obviously necessary to limit rather definitely the field of sociology, because a considerable part of the comprehensive and detailed study of society falls within the departments of political economy and public law. How the lines of demarcation ought to be drawn, with due regard to a logical classification, has been a question of practical interest to teachers, and the occasion of the recent annual meeting of the American Economic Association, in this city, was made the opportunity for a conference. The conclusion reached was that sociology is the master science that co-ordinates the special social sciences, and that, in teaching, the co-ordination must be shown not only by pointing out the interdependent relations of the different groups of social phenomena, a merely descriptive process, but by concentrating attention on those phenomena that are so elementary, or fundamental, that they are found in all groups, and are presupposed by all the special social sciences. Sociology is thus for university purposes the science of social elements and first principles, and therefore the fundamental and co-ordinating social science; a science of what is and has been, sharply distinguished from social ethics, but offering to social ethics legitimate data for a study of what ought to be.

With sociology as thus conceived more and more thoroughly taught in our universities, we may hope that the educated public will begin to entertain truer notions of what society is, and of the laws of its evolution.

MORE FACTS ABOUT DIPHTHERIA ANTITOXINE.

Since the writing of Dr. Armstrong's paper on the treatment of diphtheria by antitoxine serum, published in the Monthly for February, certain additional data have appeared that seem worth presenting to our readers.

Prof. Jaime Ferran, of Barcelona, has called attention to the fact that in April, 1890, he published a paper in which he described a safe and practical method of immunizing animals against fatal doses of the diphtheria poison, and thus he anticipated Prof. Karl Fraenkel's communication on the same subject by eight months. But, unfortunately for the Spanish bacteriologist, he did not carry his experiments to the ultimate point to which Behring carried Fraenkel's investigations, resulting in the antitoxine serum.

Recent investigations in relation to the duration of immunization have shown that the antitoxic properties of the serum of children who have had diphtheria do not appear until between the eighth and tenth days after recovery from the disease, but the property persists for several months. Antitoxic serum, however, immunizes more rapidly than the disease itself, but it does not produce a refractory state of equally long duration.

A further evidence of the value of the antitoxine serum is shown by a paper by Dr. Moizard, who administered it in two hundred and thirty-one cases of diphtheria in the Paris Trousseau Hospital, with a mortality of only 14·7 per cent. During the same months, October and November, in other years the mortality had never been less than fifty per cent. Prof. Widerhofer, of Vienna, treated one hundred patients with the serum, with a mortality of twenty-four

per cent, while the mortality in fifty cases not treated with serum was forty-two per cent. In Trieste the adoption of the antitoxine treatment has reduced the mortality from 58·3 to sixteen per cent, four hundred and six cases of diphtheria being thus treated.

Occasionally some bad effects have followed the administration of the serum, such as high fever, pain in the muscles and the joints, enlargement of the lymph glands, skin eruptions, and occasionally it seems to produce or hasten kidney complications.

The celebrated Prof. Virchow has said that while he was not such a worshiper of antitoxine serum as many of its first discoverers, and, like others, he was in doubt about many things pertaining to it that further experience might correct, still he could not refrain from saying that it was the duty of every earnest physician to use the remedy. The possibility that it would do harm was so insignificant that it might be ignored.

"*SCIENCE*."

We welcome with much satisfaction the reappearance, in an improved form, and apparently under the very best auspices, of our excellent contemporary, Science. The names upon its editorial committee are vouchers for the competence with which subjects falling into the several departments which these gentlemen supervise will be treated. The only important science which we fail to see on the list of those which our contemporary embraces in its programme is political and social science. It is true that the professors of this branch of science are not altogether at one even as regards the fundamentals of their subject; but all the more need is there for full discussion of that subject from every rational point of view. Psychology and paleontology, which *are* on the programme, are of interest chiefly as leading to wider and more intelligent views of man as a social and political animal; and we therefore trust, nay believe, that our revived contemporary, when it settles fully down to work, will have many a useful chapter to give us on the important topic to which we have called attention. Meantime we wish it, very heartily, all success.

LITERARY NOTICES.

Towards Utopia. Being Speculations in Social Evolution. By A Free Lance. New York: D. Appleton & Company. Pp. 252. Price, $1.

This is a book which we can cheerfully recommend to all who are interested in social questions. The author does not wear the badge of any school, and he writes in a style which is by no means academic. He believes in the duty of being as original as it is in one's power to be, and he therefore undertakes to apply some reforms, or what he considers such, to the accepted spelling of the English language and to some of its terms of expression. His theoretical convictions in regard to social principles are in general of the individualist order, but he is very far from being doctrinaire even on this ground. He is—to describe him briefly—a man of strong human sympathies and liberal tastes who has applied himself independently to consider the changes that will take place in society before it arrives at anything like its perfect development. The condition of perfect development he calls Utopia, and that he does not undertake to discuss or describe; he contents himself with the humbler task of describing in a discursive and very off-hand manner what he calls "semi-Utopia"—a condition of things intermediate between what we see now and the best and highest condition possible for humanity.

In the second chapter of the work occur the following excellent remarks: "Utopia can never be rightly seen otherwise than by the aid of science and a true philosophy that teach us to discriminate the possible and practicable from the impossible: the route can never be tracked by others than by pilots soundly trained in physical, psychological, and social science; and the march can never be performed by an army not disciplined and educated by the teach-

ings of science, æsthetics, and ethics." The author is not one of those speculators who disparage the work of Herbert Spencer. In the opening of his third chapter we find the following: "It has been pointed out by Herbert Spencer—who seems to have pointed out pretty nearly everything—that ideal men are possible only in an ideal state; and conversely that a perfect social state is possible only when every unit has achieved perfection." He then proceeds to consider the great gain that would result if only all men were "decently honest." He shows how much labor is at present expended in guarding against dishonesty, and how seriously the general happiness is interfered with by these protective measures. The necessity of issuing railway tickets, he observes, arises from the fact that, as things now are, hundreds and thousands of persons would steal railway rides unless they were required to present tickets. Then the tickets have to be dated, punched, and carefully collected to prevent their being used again. "Taking any church," says our author, "probably nine tenths of the 'respectable worshipers' who perform their eminently respectable devotions there every Sunday and thank God that they are children of grace and neither Turks, Jews, Socinians, nor infidels, would have no scruple in cheating a railway company on their way home." There may be, and we trust there is, some exaggeration in this statement, but that there is a large element of truth in it no one who has any extensive knowledge of mankind would be disposed to question. This matter of railway tickets is, however, only one out of many illustrations which the author brings forward of the loss entailed upon society and the diminution of happiness through the defective morality of individuals. Before we can hope to reach or even to sight semi-Utopia there must be a radical change in this respect.

The author next proceeds to discuss the "Servant Question," quoting John Stuart Mill as saying that "there is hardly any part of the present constitution of society more essentially vicious and more morally injurious to both parties than the relations between masters and servants." The word "masters" is to be taken here as including mistresses. The condition of things to which the author particularly refers is that existing in England. Some of its features have been modified in this country, but whether upon the whole we have made any sensible advance toward semi-Utopia as regards the status of the servant class may be doubted. There is more independence on one side, but what is wanted is more humanity on both sides. It would be impossible in semi-Utopia to have one class of human beings whom another class regarded as the necessary instruments of their ease and pleasure, but as cut off from them in every social sense by an impassable barrier. In that happy state, when two human beings come together in any form of association, the thought of each will be how he or she can make the relation fruitful of good in the widest possible sense to the other. People will then no longer hoard their culture and their social advantages, as if to communicate them to others would be to diminish if not destroy their value; but whatever any one has that is good he or she will try to make common. The author's whole discussion of the servant question is full of useful suggestiveness. To those who can not rise in imagination above what is sanctioned by social usage, and to those who are dominated by a selfish passion to hold on to such class privileges as they possess, many of his ideas will appear absurd; but few liberal-minded or sympathetic persons will read these chapters without acknowledging the general force and truth of the author's positions.

Following the chapters on the Servant Question we have a trenchant discussion of Luxury and Waste. Here the author's indignation waxes hot, as well it may. He points out how utterly at war with the canons of true taste all useless and ostentatious luxury is, and to what extent the higher intellectual and moral interests of society are sacrificed to a mere love of display. Here there is much we should be glad to quote, but our limits forbid. The author again defines his position by remarking (page 195): "We can thus clearly perceive the feasibility of an approximation toward semi-Utopia —*if* only men would be moderately unselfish, unwasteful, and reasonable, *It is mainly human nature that has to be changed.*" We have only in part indicated the contents of this interesting volume, but we have perhaps said enough to show the main lines of

the author's thought. The chief value of the work, in our opinion, lies in this—that it makes clear to every one of us what can be done *now*, without waiting for any of those magnificent feats of legislation which socialistic speculators promise us, to make a better society. With each one of us it rests to do something in this direction, by bringing his own life more into harmony with right reason and the dictates of pure humanity. We trust that this little book by "A Free Lance" will set very many thinking, and not only thinking but acting.

We may perhaps be allowed to point out that the author is under a singular misapprehension as to the sense of the word "hypothecate." In half a dozen places in the book he uses it as though it were the verb corresponding to the noun hypothesis. It is unfortunate that there is no word of kindred etymology to hypothesis signifying to frame an hypothesis or assume as an hypothesis; but it does not do to lay violent hands on another word of wholly different signification.

THE COLLEGE WOMAN. By C. F. THWING, LL. D., President of Adelbert College, Western Reserve University. New York: The Baker & Taylor Co. Pp. 169. Price, $1.

IF there be a vantage ground from which to view the college woman and to map out her aptitudes and shortcomings, Dr. Thwing occupies such a one as president of a university for men and of a college for women. But, after a careful reading of his book, we are forced to conclude that, however fortunate his position, he is still restricted by a lens of limited power, if not by astigmatic vision.

As seen by him, the college woman may be said to sparkle with interrogation points. Four of the questions concerning her which have been answered in the past twenty-five years are: Whether women want a college education; whether they have the necessary intellect, the physical strength; and whether the process unsexes them. Among the problems yet surrounding her are: Should woman receive the same education as man? What should be the method of her training? Do her health and manners get sufficient attention? What may the community demand of her when college-bred? What will be the result of a large influx of her species?

The principle of her education is at first stated broadly as the development of a human being; but after a review of the differentiation of sexual power according to Ruskin and an analysis of womanly nature by Dr. Thwing, the conclusion is reached that "enriching studies"—literature, philosophy, and history—should be "peculiarly precious to woman." Inquiries addressed to the collegiate alumnæ bring out the fact that a majority sensibly judge physiology and hygiene to be of special value for woman; the next largest number designate social and political science. The author recommends the adoption of the group system in order to prevent the superficiality resulting from a careless election of studies.

In regard to environment, Dr. Thwing writes: "The question of room, board, clothes, exercise, sleep, is a pretty fundamental one." Elsewhere we learn "the question of clothes is a pretty large as well as serious one," and that many women enter the collegiate year "exhausted with dressmaking"! We think the author libels the average American family when he states it is considered "crankiness in a girl" to demand an evening for study. He believes the young woman has not been generally as well housed at college as the young man, and advocates the building of small and homelike dormitories.

An entire chapter is devoted to the question of woman's health at college. The collegiate alumnæ, being interrogated, furnish many replies, and the author finally lays stress upon hasty preparation, worry, and want of exercise.

In the discussion of the method of woman's education we are introduced to an unusual form, "the co-ordinate," as one which "promotes a very sane health and healthfulness"! In this system a college for men and a college for women are conducted under one administration as parts of a university. The classes are separate, the teachers often instruct in both colleges, and the library is shared in common. The inference from the context is that by this method there is less risk of love-making than in the coeducational system; but it is

difficult to see how the classroom can prove as good a ground for this diversion as the library. The provincial note of the book is reached in the sixth chapter, Demands made by the Community upon Her. It seems obvious to us that if woman had done only what the community required of her, she would never have gone to college, and that, having gone, it is unlikely she will thereafter order her ways according to Mrs. Grundy. Such a standard is surely not an ethical goal for either man or woman, who needs to do right for right's sake, even in the face of the community.

ELECTRICITY ONE HUNDRED YEARS AGO AND TO-DAY. By EDWIN J. HOUSTON. New York: The W. J. Johnston Co., etc. Pp. 199. Price, $1.

THE author aims in this volume to give credit to every one who has contributed even in the slightest degree to the development of thought in the field of electrical science and art. The great ideas and inventions by which progress is marked are arranged in three type groups: Immature or incomplete; untimely and therefore unfruitful; and fruitful, because mature and timely; of which the first class, though having but little visible influence, may at times be of value, because of their tendency to direct thought along certain channels, thereby they become forerunners of more important ideas. The second class have to wait for recognition and effect, but eventually contribute their force to the advancing impulse; while the third class are fruitful at once. The first enunciation of ideas concerning electricity is traced back to the Greek philosopher Thales, who experimented with the attraction of a piece of amber that had been rubbed. He was much before his time, for no advance was made on his experiment till near the close of the sixteenth century, when Dr. Gilbert showed that powers of attraction and repulsion are developed in several other bodies by rubbing them. Stephen Grey, in 1729, first pointed out the distinction between conductors and non-conductors of electricity. The power of wires to conduct the electrical force to a distance attracted attention and excited inquiry, in the course of which Watson, in 1747, erected conducting lines several miles in length, and used the earth as a return conductor. He was succeeded by Franklin, whose experiments are familiar, and were followed by the rapid development of electrical discovery which has not yet slackened. The invention of the electric telegraph, with the discoveries that made it possible and led up to it, and of the telephone, are reviewed in a very clear and comprehensive manner. The application of electricity as a motive power and light producer was first made commercially practicable after the invention of the Gramme dynamo. Since then it has been rapidly extended, and is likely to become general all over the earth, and as to all kinds of machinery. Still more wonderful expansions of electricity seem to be foreshadowed by the discoveries of Hertz, Tesla, and other workers of the day. As possible features of this future expansion, Mr. Houston dreams of a cheaper means for the production of electricity than is possible by the present method; perhaps producing it directly from the burning of coal; the entire replacement of the steam engine by the electric motor; the successful solution of the problem of aërial navigation, effected, possibly, by means of the electric motor, and being rendered possible as a result of improvements in the economical production of electricity; the replacing of the present electric light, with its preponderance of useless and injurious low heat rays, by some species of electrically produced light which shall possess a smaller proportion of the useless heat rays and a larger proportion of the desired light rays; a more intelligent means than are now adopted in the therapeutical applications of electricity to the curing of diseases; electrical transmission of pictures; electrical preparation of roadbeds by vitrifying the clay or soil *in situ*; and "an apparatus for the automatic registration of unwritten, unspoken thought, and its accurate repetition at any indefinite time afterward."

SCIENCE. A Weekly Journal devoted to the Advancement of Science. 41 East Forty-ninth Street, New York. Pp. 28. 15 cents a number; $5 a year.

WE are glad to see the publication of Science resumed. There certainly is room, as Prof. Newcomb well observes in an editorial address to its readers, for a journal de-

voted to the promotion of intercourse among those interested in the study of Nature; and the wide separation of investigators in different centers of educational and civic life makes such a journal almost a necessity. Science, under its new auspices, will be conducted by an editorial committee of chosen students, each representing a field in which he is a specialist, and under the general editorial direction of Prof. J. McKeen Cattell. In the first number of the new Science, Prof. Newcomb explains the scope of the journal, and President Gilman invites communications from those who have matter suited to it. The leading place among the regular articles is given to a part of Dr. Brinton's American Association address on the Character and Aims of Scientific Investigation—a most appropriate subject with which to open the first number of the new journal; which is followed by the equally appropriate review of America's Relation to the Advance of Science, by G. Brown Goode. Prof. T. C. Mendenhall gives an account of the Legal Units of Electrical Measurement, now sanctioned by act of Congress. Major Powell discusses what in education are technically called the Humanities; Prof. C. Hart Merriam furnishes notes on Zoölogical Nomenclature; S. H. Scudder discusses the study of North American Orthoptera; several reviews of books appear; and notes are published on a variety of subjects.

SEA AND LAND. By N. S. SHALER, Professor of Geology in Harvard University. Illustrated. New York: Charles Scribner's Sons. Pp. 252. Price, $2.50.

EVERY thoughtful person who visits the seaside must have queried why there is in one place a gently sloping beach of sand, in another a stretch of loose stones, and elsewhere a ragged cliff rising abruptly from the water's edge, with a fringe of fragments at its foot. He who has voyaged upon the open sea has wondered how the fantastic icebergs that float by him were formed and what the dark depths of water beneath him may conceal. To answer these and similar questions Prof. Shaler's book has been prepared. He explains first what forces are at work carving the edge of the land and how different effects are produced under different conditions. Passing to the depths of the sea, he tells how our knowledge of the ocean floor has been obtained, and describes the processes going on upon it. The career of an iceberg is then sketched, after which the subject of harbors is discussed at some length. The different kinds of harbors are distinguished, and the ways in which they are formed or destroyed are described, the effects of tide and the work of animal and vegetable organisms finding place under the latter head. The book is handsomely printed and is embellished with many full-page illustrations as well as smaller pictures in the text.

AN ELEMENTARY CHEMISTRY. By GEORGE RANTOUL WHITE, A.M. Boston: Ginn & Co. Pp. 272. Price, $1.10.

THE teacher who likes to roll along in a rut would be a good deal disturbed by this book; it is so different from other books. It is an experimental text-book, but it is different from others of this class. The various chemical properties and relations of matter are taken up in the order in which the author believes they can be learned most readily and profitably—not according to any logical or systematic arrangement. The first thing the student is told to do is to test the properties of iron, and cause it to combine with oxygen. The method of the book is to require the student to start from observations upon things and to arrive at general laws and principles by induction. Taking statements on authority is discouraged. In the words of the preface: "At first the student is told little or nothing. He is compelled to find out all things for himself. To assist him in finding the essential, and to make sure that he has succeeded in this, frequent questions are inserted in the text of the experimental part." Gradually proceeding to more complicated cases, the author finally puts before the student, under the head of A Chemical Investigation, such a problem as the chemist has who is working on the borderland of the science. After going through this experimental drill the student is led to trace the history of chemistry, "to note what observations lead to the establishment of certain theories, and the recognition of what facts lead to the overthrow of these same theories; to recognize the gradual unfolding of chemical law; and, finally, to

inspect the foundations on which our present atomic theory rests, and have an opinion of his own as to its stability." Another feature of the book is that chemical symbols are not used until the need of them has been made apparent. Full and practical directions for manipulating apparatus, taking notes, etc., are given. The author is instructor in chemistry at Phillips Exeter Academy, and the book is adapted to the needs of academy students.

A MANUAL OF MICROCHEMICAL ANALYSIS. By Prof. H. BEHRENS, of the Polytechnic School in Delft, Holland. With 84 illustrations. London and New York: Macmillan & Co. Pp. 246. Price, $1.50.

SEVENTEEN years ago the Bohemian chemist Boricky published a memoir which gave rise to a new branch of chemistry. This is microchemical analysis. Other investigators have contributed to its advance, and now one of them gives us a view of its present condition. Devised for the examination of minute quantities of minerals, it has been applied also to alloys, and Prof. Behrens expects it to rival blowpipe analysis in convenience and value. The method consists in dissolving a particle of the substance to be examined, adding a minute drop of reagent to a drop of the solution, and observing the result through the microscope. Often the drop of solution is evaporated and the form and color of the crystals it deposits are observed microscopically. Something may be learned of the composition of alloys by heating polished surfaces or etching them with acid. The practical applications of all these and many other devices are described in the manual before us, and the forms of the crystals of many substances are shown in engravings.

THE EGYPTIAN BOOK OF THE DEAD. The Most Ancient and the Most Important of the Extant Religious Texts of Ancient Egypt. Edited, etc., by CHARLES H. DAVIS. New York: G. P. Putnam's Sons. Pp. 186, followed by Ninety-nine Hieratic and Hieroglyphic Plates. Price, $5.

THE Egyptian Book of the Dead is one of the most remarkable books in existence. Parts of it are among the oldest texts extant, some of its chapters having been inscribed in the tomb of the Queen of Mentuhotep, of the eleventh dynasty, and one of them being ascribed to the pen of the god Thoth. Very few of the Egyptian manuscripts are of earlier date. It is, further, most obscure as to its meaning. In a literal translation it is pure nonsense, and its real meaning has to be incorporated into it from the knowledge of the ancient mysteries possessed by the reader. Some of the old priests probably comprehended it; and the more advanced of the Egyptological students of the present are gradually getting glimpses of its significance. It is essentially mythological, Mr. Davis says, "and assumes the reader's thorough knowledge of the myths and legends. No one is capable of translating a single chapter of the Book of the Dead who has wrong ideas about the religion and mythology of Egypt, and is unable to understand the numerous technical and mystical expressions which everywhere occur. It is not always easy to discover what was the primitive concept attached to a particular word. The difficulty is not in literally translating the text, but in understanding the meaning which lies concealed beneath familiar words. However, the mystical nature of the text is gradually being unraveled, and, no doubt, will be ultimately understood. But we will have to make further researches into unwritten history, or perhaps have a fuller knowledge of Egyptian symbols or allegories." The text is further obscured by errors of copyists, and muddled by comments and attempts to explain the meaning which have been interpolated into it and made by subsequent copyists to run on as if they were part of the original. The purpose of the book—which is often called the Funereal Ritual—was to instruct the soul in that which would befall it after death, and to furnish prayers to protect it against dangers and assure it desired blessings. "It was given to the departed to carry with him to the grave as a passport and aid to the memory." Accordingly, more or less of it, according to the means of the deceased, was wrapped up with the mummy or inscribed on its coffin or on the walls of its tomb. About a thousand copies of it exist among the papyri of European museums, and some hundreds in Egyptian home collections. The longest copy known is the Turin hieroglyphic papyrus, containing one hundred and sixty-five chapters, which is reproduced in this volume. Yet it is not com-

plete, for many chapters found in other copies are not contained in it. Of the translations, Dr. Samuel Birch's, made thirty years ago from the Turin papyrus, is literally correct, but nonsense. A more intelligible translation of it has been made by M. Pierret, and an exact and scholarly translation is in preparation by Dr. Le Page Renouf; while careful studies of it have been made by Lepsius, M. Edouard Naville, and M. Renouf. The translation of Mr. Davis is made, with that author's permission, from M. Pierret's version in French, and is purposely rather exact than graceful; and it has been revised in the light of the additional knowledge that has been gained since Pierret's work was published, in 1882. Excellent and valuable preliminary chapters are given on The Mythology and Religion of Primitive Peoples; The Egyptian Pantheon, with illustrations of some of the more important deities; The Mythology of the Ancient Eygptians; and a historical and critical introduction to the book.

A TEXT-BOOK OF INORGANIC CHEMISTRY. By G. S. NEWTH, F. I. C., F. C. S. London and New York: Longmans, Green & Co. Pp. 667.

THE periodic classification has been taken as the basis for the arrangement of the matter in this fully detailed treatise. Definitions and principles are placed in the fore part of the book, but the student without a teacher (suggestions to teachers being delicately withheld) is advised to study only four of the fifteen chapters of such material before taking up the descriptions of the four typical elements—hydrogen, oxygen, nitrogen, and carbon—and their compounds, which constitute the second division of the work. The other elements are taken up by subdivisions of the periodic system, beginning with "Group VII, family B," and ending with the "transitional elements of the second and fourth long period." The four elements first named are taken up out of their order so as to bring well forward such subjects as water, the atmosphere, and combustion, to which the student should be introduced at an early stage. Only general descriptions of the rare elements and their compounds are given, and technological details of metallurgical processes are dispensed with. While the performance of experiments by the student is strongly urged, another book by the same author is referred to for the necessary directions.

RADIANT SUNS. A Sequel to Sun, Moon, and Stars. By AGNES GIBERNE, with a Preface by Mrs. HUGGINS. New York: Macmillan & Co. Pp. 328. Price, $1.75.

IN this work the author has tried to avoid treading in the same grooves, and to make a book entirely supplementary to Sun, Moon, and Stars, in which subjects which could there be merely glanced at should be entered more closely into, and difficulties explained which could not there be dealt with, and which should give a large amount of fresh information. The book falls into three divisions—a history of astronomy, in which short outlines are given of the lives of the greater astronomers of the past; a discussion of spectrum analysis, what it means and what it teaches; and a view of the stellar universe as it is now known, with references to some great theories which may in future gradually take their places as proved truths. Mrs. Huggins finds value in this book and its predecessor, not only in their describing well the facts of astronomy, but also in their appealing constantly and wisely to the imagination in a way that can not fail to give mental training to their readers. "Indeed," she says, "there are few pages in the present work in which, beyond the scientific information directly given, there is not also enforced indirectly some lesson of high practical value."

THE LIFE OF RICHARD OWEN. By his Grandson, the Rev. RICHARD OWEN, M. A. Also an Essay on Owen's Position in the History of Anatomical Science, by the Right Hon. T. H. HUXLEY, F. R. S. With Portraits and Illustrations. New York: D. Appleton & Co. Two Volumes. Price, $7.50.

A LIFE extending over all but the first four and last eight years of the present century, and devoted to biology in connection with several of the leading scientific institutions of Great Britain, could not fail to have strong features of interest. When sixteen years of age Richard Owen was apprenticed to a "surgeon and apothecary." Later he attended lectures at Edinburgh, whence he went to London and studied under Aber-

nethy. Soon after he had begun to practice his profession Abernethy, who had noticed the peculiar ability of his pupil as a dissector, obtained for him an appointment to arrange and catalogue the collections formed by John Hunter. Two years later he was appointed a lecturer at St. Bartholomew's Hospital, and after six years became Professor of Comparative Anatomy at the same institution. This was in 1834. In 1836 he was appointed Hunterian Professor at the Royal College of Surgeons, and the next year the professorship of anatomy and physiology was also assigned to him. As Hunterian Professor Owen delivered twenty-four lectures annually until 1855, making them illustrate Hunter's collections, and without ever repeating a subject. His time was now fully occupied with lecturing and scientific research. In the year 1831 he had published eight papers on the anatomy of various creatures that had died in the Zoölogical Gardens. His memoir on the Pearly Nautilus, published in 1832, "placed its author, at a bound, in the front rank of anatomical monographers." In his memoirs on the anthropoid apes, the monotremes, and the marsupials Owen gave the most complete accounts of the structure of these animals then extant. Memoirs of similar character on the apteryx, great auk, and dodo were produced by him. He discovered that terrible parasite the *Trichina*. His researches on fossil forms were also important. Says Huxley, "Unless it be in the *Ossemenes Fossiles*, I do not know where one is to look for contributions to paleontology more varied, more numerous, and on the whole more accurate than those which Owen poured forth in rapid succession between 1837 and 1888." His studies in philosophical anatomy were directed chiefly toward the "archetype" of the vertebrate skeleton and the problem of parthenogenesis.

The story of such a life, with its accompaniment of struggles, labor, recreation, domestic affairs, and honors, is told in the two volumes before us. The material for this biography was plentiful and highly satisfactory, consisting of twelve hundred letters from Owen to his wife and sisters, besides many to other persons, and fifteen thousand received by him in the course of his long life, also the diaries kept by him and his wife. The journal of his wife is a full record not only of the important facts but also of the trivial details of their joint lives, and large use has been made of it. By its aid we see Owen attending meetings of scientific societies and committees, with an occasional dinner, public or private, writing late into the night on his lectures or monographs, receiving leading naturalists at his house for consultation or study with the microscope, and now and then going with his wife to the zoölogical garden, or for an evening's recreation at the theater. Music and novels were other recreations that he greatly enjoyed. His visits to various parts of Great Britain and the Continent are described in very readable letters to some member of his family who did not accompany him. Many comical incidents and characteristic anecdotes of celebrated persons give a genial warmth to the recital.

Prof. Huxley's essay traces the progress of comparative anatomy before 1830, sets forth Owen's contributions to the science, and discusses his views on the "archetype" and "parthenogenesis." His conclusion in regard to Owen is that "his claims to a high place among those who have made great and permanently valuable contributions to knowledge remain unassailable." A bibliography of Owen's publications and a list of his honors close the record.

A HISTORY OF AMHERST COLLEGE. By WILLIAM S. TYLER, D. D., LL. D. With an Introductory Note by RICHARD SALTER STORRS, D. D., LL. D. Published by subscription. Frederick H. Hitchcock, 55 West Forty-fifth Street, New York. Pp. 312. Price, $1.50.

A HISTORY of Amherst College, forming a substantial octavo volume, was written by Dr. Tyler soon after the fiftieth anniversary of the institution, in 1871. He has now told the story of the college in smaller compass and brought it down to the close of President Seelye's administration, in 1890. The labors of the founders of the college, the financial struggles of its early years, its period of depression and triumphant recovery, and its later years of increased usefulness through enlarged resources are set forth in a way to compel the respect of all friends of education. Although Amherst was founded for the education of preachers and missionaries, and "the gift of tongues" was deemed a

prime need of its students, science was represented by chemistry and anatomy in its earliest course of study, and rapidly increasing facilities have since been accorded to it. Amos Eaton lectured on chemistry and botany in the early years of the college. Prof. Snell, with a wonderful Yankee handiness in constructing apparatus, had charge of the teaching of physics for many years. The instruction of these men, together with that of Shepard in mineralogy, of Adams in zoölogy, of President Hitchcock in geology, and the younger Hitchcock in physiology, has enabled the students of Amherst to go forth into the world with some understanding of Nature, of which man is no longer ashamed to confess himself a part. The volume is generously illustrated with portraits of the several presidents, and views of the buildings and grounds of the college. An appendix contains a list of donations to the college, the number of faculty and students year by year, etc., and there is a full index. The book will appeal strongly not only to the alumni of Amherst but also to every New-Englander who is proud of the educational institutions of his native section and to friends of learning everywhere. A limited *édition de luxe* at five dollars is announced.

Three reprints, from the Transactions of the Fifth Session of the International Congress of Geologists held in Washington in 1891, are geological, geographical, and topographical descriptions of the *Great Plains of the North* and of *the Yellowstone Park*, by Arnold Hague; and a paper in French by Lester F. Ward, on the *Principles and Methods of Study of Geological Correlation by Means of Fossil Plants.*

Science Progress is a new monthly review of Scientific Investigation, published by the Scientific Press, Cambridge, England, and edited by J. Bretland Farmer, with the co-operation of a number of investigators, masters in their several fields. Profs. Armstrong, Burdon-Sanderson, Dunstan, Fitzgerald, Goebel, Halliburton, Ray Lankester, Roy, etc., are named as among the contributors to the earlier numbers. The articles are of high character, about midway between the popular and the technical—that is, within the understanding of the general reader, but requiring thoughtful attention.

Dolls of the Tusayan Indians is the subject of an interesting paper published originally in the *Internationales Archiv für Ethnographie*, by *J. Walter Fewkes.* The dolls are illustrated in a series of striking pictures, colored like the originals, and described as examples of wood-carving and symbolism among the Hopis. This art, according to the priests, is very ancient; and many of the objects placed on the altars in subterranean chambers where secret rites were performed are said to have been brought up from the under-world when the ancients emerged from the *si-pa-pu*, or traditional opening in the earth out of which the races of man originally appeared. The images, often called idols, but in reality only dolls, are made in great numbers by the Tusayan Indians and present very instructive objects for the study of symbolic decoration. They are interesting as affording valuable information in regard to the Hopi conception of their mythological personages.

Recreation is a new monthly magazine "devoted to everything that the name implies," of which *G. O. Shields* is editor and manager, and which is published at 216 William Street, New York, for $1 a year. The first number contains a varied table of contents, of which the most striking articles are President D. S. Jordan's How the Trout came to California, and Captain H. H. Bellas's A Winter with the Cheyennes; and the illustrations are very attractive.

The second part of *Clarence B. Moore's* memoir on *Certain Sand Mounds of St. John's River, Florida*, represents the results of seven additional months' continuous work subsequent to the preparation of the first part, with a large body of assistants. The river has been covered practically from its source to its outlet, and the author believes that every mound of any importance bordering on the stream, except two on Murphy Island, has been examined. The descriptions are liberally illustrated with representations of the objects recovered from the mounds. A separate reprint is also published by Mr. Moore from the memoir, on the copper found in the mounds—*As to the Copper from the Mounds of the St. John's River, Florida.* In this paper are considered copper objects of European and of aboriginal design, the archæological aspects of the finds, and the re-

sults of chemical examinations. The conclusions as summarized are favorable to the aboriginal origin of the copper, and point to the Lake Superior region as the main source of supply.

The Progress and Trend of Scientific Investigation in Canada is the subject of the presidential address of 1894 of *George M. Dawson* as President of the Royal Society of Canada. The address presents the work of the Geological Survey, the Meteorological Service and Magnetic Observatory, the Dominion Lands Survey, experimental farms, the hydrographic surveys, the study of the fisheries, the Literary and Historical Society of Quebec, the Natural History Society of Montreal, the Canadian Institute at Toronto, the Entomological Society of Ontario, the Literary and Scientific Society of Ottawa, the Botanical Club of Canada, and the Royal Society of Canada.

A paper by *Edward A. Burt*, on a new species of fungus—*A North American Anthurus, its Structure and Development*—constitutes No. 14 of the third volume of the memoirs of the Boston Society of Natural History. This *Anthurus* was found growing in a sandy cornfield on a hillside near East Galway, N. Y., where it was represented by thirteen discovered mature individuals and several "eggs" in various stages of growth, and is the only species at present known in the northern continents. Two other species are known in South America and one in Australia, the differences from which of this species are pointed out. It is named *Anthurus borealis*. The paper is accompanied by two plates of illustrations of structure.

Around the World, an illustrated magazine of tours, travels, and natural history, devoted to a knowledge of the earth and of its inhabitants, of which Prof. *Angelo Heilprin* is editor, began its second year with the number for December, 1894. It has been received with a favor, the publishers represent, both by the general public and by specialists in scientific work, which emphasizes the need of a magazine covering its special field. Its general appearance and make-up go far to justify the claims its friends set up, that in its own field it stands alone in this country, and "in its pictorial features it surpasses all similar publications of the Old World." The December number contains articles on Wintering on the Riviera, The Pygmies of the Congo, Among the Thibetans, American Cave Dwellers, The Sargasso Sea, Notes on Mountains and Mountaineering, Hints to the Traveler and Notes on Appliances of Travel, and full-page illustrations of Popocatepetl, Bellagio, on Lake Como, Cliff Castle, and the Zebra. (Monthly: The Contemporary Publishing Company, New York and Philadelphia; 15 cents, $1.50 a year.)

The Mechanism of Weaving is designed by the author, *T. W. Fox*, to supply what seems to be a deficiency of books in which the mechanical side of the art is made prominent. Several admirable books have been written on weaving during recent years, but in them attention has been predominantly directed to designing, fabric and structure, and calculations relating thereto. The present work aims to put within the reach of the student, in as comprehensive a manner as possible, exact and practical information bearing upon the principles of weaving as exemplified in the various processes of the trade. Numerous topics of practice are treated, beginning with the description of the power loom, and continuing with chapters on healds, shedding or dividing the warp, over-and-under motions, the figuring harness, card cutting, picking, and other movements or elements of the art, described in detail. (Published by Macmillan & Co. Price, $2.50.)

A collection of *Lectures on Biology*, reprinted from the American Field, contains four lectures on that subject delivered by Dr. *R. W. Shufeldt*, on invitation, at the Catholic University of America, in January, 1892. The first lecture relates the history of biology and defines its present domain, and calls attention to the light it casts upon the unity of organization among plants and among animals, and upon the interdependence of the various natural divisions of science. The second lecture considers its relations to geology. The third treats of its value as a study to the medical man and to every student of Nature, as well as to the professional biologist. The fourth lecture forecasts its future growth and influence, showing how it has affected the trend of human thought, and now demands a prominent place in any scheme of education worthy of the name,

and predicts that its beneficial influence is destined to be felt in every field of activity in which men engage.

PUBLICATIONS RECEIVED.

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American Public Health Association Journal, January, 1895. Quarterly, Concord, N. H. Pp. 125. $1.25; $5 a year.

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Bardeen, C. W. Roderick Hume. The Story of a New York Teacher. Second edition, from new plates. Syracuse, N. Y.: C. W. Bardeen. Pp. 319. 50 cents.

Bhikshu Subhâdrâ. A Buddhist Catechism. New York: G. P. Putnam's Sons. Pp. 107.

Bryant, W. C. The American Scheme of State Education. St. Louis: W. B. Bell Book and Stationery Company. Pp. 66.

Call, Richard Ellsworth. The Life and Writings of Rafinesque. Louisville, Ky.: John P. Morton & Co., Printers to the Filson Club. Pp. 227. $2.50.

Carhart, H. S. Physics for University Students. Part I. Mechanics, Sound, and Light. Boston: Allyn & Bacon. Pp. 344.

Chittenden, F. H. Two New Species of Beetles. Pp 2.

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Conn, Prof. H. W. The Biological Laboratory of the Brooklyn Institute, Cold Spring Harbor, L. I. Frederick Mather, Superintendent. Pp. 8.

Davies, T. A. Reading the Bible by Co-ordinates of Truth. Pp. 32. New York. Free.

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POPULAR MISCELLANY.

Transportation of Dust in the Air.—In his studies of the atmospheric transportation of matter, Prof. J. A. Uddin finds that the velocities in the atmosphere being so much greater than those obtaining in rivers, lakes, and seas, the distances over which materials may be transported in it will be correspondingly greater, as was shown by the Krakatoa dust, of which the finer particles circled round the earth for months and even years. The greater depth of the aërial ocean renders it but little dependent in its movements on smaller elevations of the land. Few of our mountain ranges are so high as to stand materially in the way. "While the conditions requisite for much aërial erosion are limited to rather small areas of the land of the globe, there can be little doubt that deposition is much more general and widespread; for dust is carried everywhere, and if it be conceded that the atmosphere is never entirely free from dust, it follows that sedimentation occurs wherever and whenever there is a comparative calm. In places in the ocean where sedimentation is known to be very slow, atmospheric dust may be supposed to form an appreciable part of the deposits. The areas of deposition being much greater than the areas of erosion, it is evident that the accumulations of atmospheric sediments, as a rule, are insignificant, only exceptionally exceeding on the land the secular erosion by water, and therefore accumulating only in such exceptional cases. From a dynamical point of view the wind theory would appear to furnish an adequate explanation of the occurrence of the loess in the Mississippi Valley, at least as to most of its phases."

Habits of Polar Bears.—Appropriately to the recent mortal illness of the large polar bear in the London Zoölogical Gardens, a writer in the London Spectator remarks upon the mistake we make in supposing that the denizens of the frozen north necessarily suffer unduly in warmer climates, that "in all stories of arctic travel the extreme of cold appeals so strongly to the imagination that the heat of the nightless summer, in which the Eskimos strip themselves naked in their snow houses, is often forgotten. The good health and long life of the polar bears in this country [England] is less surprising than it at first appears when this extraordinary range of arctic temperature is remembered; moreover, the white bears are absolutely indifferent to fog and wet. Creatures that live and thrive on islands like Nova Zembla, where half their life is spent in fog and darkness, are little troubled by the London fog and damp of Regent's Park. . . . They will plunge and roll in the bath with as much pleasure in pouring rain or when the tank is full of clinking ice as on a hot summer day, and the only weather which seems to cause them discomfort is a hot August afternoon, when they pant and loll out their tongues like Newfoundland dogs." The size of these bears approaches that of the ox or the elephant, rather than that of the true carnivora. In some respects the bears' powers of movement exceed those of cats. They "can maintain a gallop at a pace equal to that of a fast horse, leap wide gulfs with ease, swim fast enough to catch a salmon, and dive like a seal or an otter. They heartily enjoy their play, but are dangerous animals. No creatures are more carefully kept at arm's length by their keepers. Men who will rub their hands over a lion's face and eyes or pat the neck of a tiger, shift a bison bull across its stall like a bullock, or handle a python like a length of rope, would think it rash to put hand or limb within reach of these bears. . . . The fierceness of the polar bear is probably due to his enforced carnivorous diet. Every

other bear is largely a fruit, vegetable, and insect feeder; but in the frozen north the polar bear lives by necessity mainly on fish, carrion, seals, walruses, and birds. Its notion of an 'egg for breakfast' is rather amusing. It will clear an islet of eider-ducks' eggs in a few hours."

Dispersal of Fresh-water Shells.—A recent book by Mr. H. W. Kew deals with the means by which fresh water and land shells are dispersed. The occurrence of these shells is sometimes very puzzling, as when fresh-water shells are found in isolated ponds. It is surprising how varied the means of distribution are. The animals are carried down stream on various floating objects. A case is cited by the author in which a number of anodons were carried away by a whirlwind and fell with the rain. Canon Tristram found the eggs of a mollusk attached to the foot of a passing mallard which he shot in the Sahara a hundred miles from water. A few instances have been noted in which birds on the wing have been shot with bivalves adhering to their toes. Insects also lend their aid, and a water-beetle has twice been captured on the wing with *Sphærium* attached to its legs. Another specimen was caught with *Ancylus* attached to its wing-case, and other aquatic insects have been found with mollusks attached to them. The actual process of transportation of land shells has not often been observed. Some live snails were once found in the stomach of a wild pigeon three days after it had been shot, and an operculated land snail has been found dragged along on the foot of a bumblebee on which it had caught. An isolated dew pond after an existence of ten years will generally yield several species of fresh-water mollusca, and a mediæval fish pond has a considerable fauna. A church or castle built of limestone, but surrounded by non-calcareous desert, is for a large group of land snails the equivalent of an isolated pond; but it is only on very old buildings that one finds colonies of the special limestone species. Mr. Kew also discusses the dispersal of shells by human agency.

Hearing of Infants.—In her Notes on the Development of a Child, issued in the series of University of California Studies, Milicent W. Shinn reports that the infant started violently while nursing, when a paper was torn some eight feet away, on the third or fourth day after birth, and at several times on that and the few following days she started and cried out even in sleep when a paper was rustled sharply as her father sat by the bed. During the first week she did not seem to notice when on his return in the afternoon her father sat close by, reading aloud or talking, but in the second and third weeks she always became restless at this time. The more modulated voices of women who were in the room the rest of the time appeared not to affect her at all. The sensitiveness to sound seemed variable, for on the twenty-third day, when Miss Shinn purposely rustled paper near the baby, it produced no clear reaction, nor did a table call bell struck suddenly and sharply at two feet and even one foot from her head. On the twenty-seventh day she showed no sign of hearing *single notes* on the piano from the highest to the lowest, yet she started at a hand-clap behind her head. Ten days later, while the baby was lying half asleep on Miss Shinn's lap, the servant brought in a tin bath tub and set it down abruptly so that the handles rattled. The infant started violently with a cry so loud that it brought in her grandfather from two rooms away to see what was wrong. She also put up her lip with the first crying grimace she had ever made, and showed the effect of the fright in a disturbed face for five minutes. Yet throughout the first two months there were also many times when she failed to pay any attention to sounds quite as striking as the few she did notice. The great variation in sensibility was especially noticeable in the second month.

The Tropical Climate.—Respecting the climatology of tropical Africa, E. G. Ravenstein represents that by ascending a mountain we might, even in tropical Africa, enter a region the mean temperature of which coincided with that of England; but if we at the same time considered the annual and daily ranges of temperature, we should find that a tropical climate differed exceedingly from that of the temperate regions. In the latter the annual range was considerable, the daily range small. The character of a tropical climate was the very reverse, for there

the difference between the coldest and warmest months of the year was small, while the difference between the temperature of day and night was very great. Nor could we escape these features, even though we ascended the loftiest mountains to be met there. These conditions inevitably led to anæmia and racial degeneracy. Malaria prevailed throughout, even on the plateaus, and some of those explorers who had been loudest in praising the climate as being thoroughly well adapted to European constitutions had fallen victims to its deleterious influences. Europeans might certainly "live" in Africa with occasional holidays in Europe, and they could superintend native labor, but no locality had been discovered as yet where it would be advisable for European agriculturists and colonists to settle down. The districts most favorable to European settlers appeared to him to be some of the hill stations and the steppelike plateaus which occupied so large an area in eastern Africa, and extended southward into Cape Colony. Speaking of the rainfall, Mr. Ravenstein said that it was sufficient in most parts, but very irregular, so that works of irrigation would be required wherever agriculture on an extensive scale was to be carried on. The humidity, which in combination with great heat produced a climate very trying to the strongest constitutions, was, fortunately, not excessive over a considerable portion of Africa, including all the steppe lands.

Human Characteristics in Apes.—Human characteristics, according to Dr. Lydekker in Knowledge, are most largely developed in the teeth and jaws of the young of the manlike apes and of the gibbons at all ages, and in the skull of the former class. Among other features in which the manlike apes differ from monkeys and resemble men are the absence of dilatable pouches in the cheeks for the storage of food, the loss of the tail, and the flattened instead of laterally compressed form of the breastbone. The gibbons alone retain the naked patches on the buttocks characteristic of the monkeys, but only in a much reduced condition. The gorilla and chimpanzees further differ from the other members of the group, and thereby resemble man alone in the loss of the so-called central bone of the wrist—a bone occupying a nearly central position between the upper and lower rows of small bones of which this joint is composed. What may be the object of the disappearance of this bone it is not easy to say, but the fact that it is wanting in the two genera of apes just mentioned is very significant of their close structural affinity with man. In one respect the manlike apes stand apart from both the human and the monkey type, namely, in the great relative length of the arms as compared with the legs, the disproportion being most strongly marked in the gibbons, which are actually able to walk in the upright posture with their bent knuckles touching the ground. The present distribution of the anthropoid apes clearly points to the existing species being the last survivors of a group which was once widely spread over the Old World, when warmer climatic conditions prevailed over what we now call the temperate regions. Of the four existing genera of manlike apes the chimpanzees (*Anthropopithecus*) are clearly those which come nearest to man. The chimpanzees and the gorilla alone resemble man in having seventeen vertebræ between the neck and the sacrum, and likewise in the absence of the central bone in the wrist, although they differ in the comparatively unimportant feature of possessing an additional pair of ribs. The gibbons, while they are much differentiated from man, are the only apes which habitually walk in the upright position; and although they frequently aid themselves by applying the hands to the ground, they often while walking clasp them together at the back of the head. In addition to this peculiarity these creatures are remarkable for the extreme agility of their movements and their loud, unearthly cries. The delicacy of their touch is well marked. It is shown by the animals in the London Zoölogical Gardens when they amuse themselves by playing with spiders, which they allow to descend by spinning a thread attached to a finger, then suddenly jerk them back into their hands, and eat them with evident relish.

Exploration of the Upper Air.—Among the ways in which the upper air may be explored for the determination of its physical and dynamical qualities, Prof. M. W. Harrington, chief of the Weather Bureau, men-

tions investigation of the ray of light that has passed through it by spectroscopic examination and by observations of the twinkling of the stars and of the fluctuations on the margins of the larger celestial bodies when viewed in the telescope. The information obtained in these ways must, however, always be vague, because the total result received by us is the integration of the individual effects at each point of the path, and it is not practicable to separate the sum into its parts; while the knowledge obtained would be otherwise incomplete. Other means of systematic exploration of the free air are by towers, like the Eiffel Tower in Paris, kites, pilot balloons (without aëronauts), and balloons carrying aëronauts. Towers do not reach to the height it is desired to explore. The method by kites has been studied especially by Mr. William A. Eddy, of Bergen Point, N. J. Mr. Eddy uses tailless kites, placing them in tandem, and recommends that they be flown in groups of three. By such means he has attained heights of between four thousand and five thousand feet, and expects to reach fourteen thousand feet without great difficulty. Three tailless kites will fly when any one of the three will not in mild surface winds. They easily right themselves when reversed, and a tandem series of kites tends to prevent the jerking which might put the instruments out of order. The best possible anemometer is a balloon which is immersed in the air and moves freely with it. While such balloons can be employed only for the study of air currents, by a proper selection of places and dates and the assistance temporarily of theodolites and persons capable of working with them they could be made very useful. They would enable us to study the arrangement of air currents about definite meteorological phenomena, such as centers of high or low pressure. A more instructive but more expensive method is that of pilot balloons carrying automatic registering instruments. Balloons sent up by M. Hermite in 1892 carried means for the automatic record of pressure and temperature, but were disabled from registering the temperature by the cold stiffening the ink. They also carried a device for releasing and dropping cards for tracing the course of the balloon, which did not operate very satisfactorily. Much better service than this would be given by systematic work by a meteorologist who would make the ascension himself. Evidence points to the conclusion that the cloud layer and perhaps the upper cloud service is a region of especial activity in meteorological phenomena, but the facts on which such a conclusion could be verified are of such character that they would probably escape any automatic registry. Prof. Harrington furnishes estimates showing that the cost of operating any of these methods could be brought within reasonable limits.

Telpherage Lines.—The telpherage method of transportation is much better known in Spain, Italy, and the British colonies than in England and the United States. Its history may be hypothetically traced as an evolution from the single-rope bridges of the Himalayas and Thibet — cables made of twisted birch twigs on which the passenger crosses seated in a hoop, which he hitches forward while he holds the rope above with his hands. The next development is to fasten a cord to the hoop by which it is drawn to either side. A similar rough form of transport, except that buckets and wheels were used instead of the hoop, was employed for many years in the lead mines of the Peak of Derbyshire. A great impulse was given to the method by the invention of twisted steel cables, which made the lines stronger and more lasting. More than two thousand miles of telpher line are now in working order in Spain, Italy, South America, India, Cape Colony, China, and Japan. A line at Hong Kong, rising ten hundred and ninety feet in two miles, is used for the transportation of the European workmen at the port up the mountain at night, in order that they may sleep in purer air. It is led straight up the mountain side on high steel trestles, and carries, in little back-to-back cars, three persons on each side. At Table Mountain, Cape Colony, the suspending wire is carried in a single span fourteen hundred and seventy feet to the edge of the cliff, and thence in another span fourteen hundred feet to the top of the mountain. At the Rock of Gibraltar the wire runs, after a first leap of eleven hundred feet, straight to the summit on a series of lofty trestles in an ascent of one foot to every foot and a half. At

Bilbao, in Spain, nine lines run from the station at the foot of the mountain to the mines at different levels along the summit, and carry on an average twenty-three hundred tons of ore a day, none of which touches the level of the ground through its journey of five miles. It is calculated that one hundred thousand tons of ore can be carried on each of these cables before it becomes unfit for service. In crossing wide ravines or rivers, where one bank is lower than another, the gravity system is employed, the descending load being used to haul up the ascending car. In the Italian Alps a span of fifteen hundred yards is crossed without a support, and the method is soon to be applied to distances of two thousand yards.

Effects of Freezing on Plants.—The study of the effects of freezing upon plants has made less advance than that upon the best temperature to promote their growth. Some observations on the subject have been published by Signor Sebastiano Cavallero in Italian journals. All plants, aside from a few tropical species, resist temperatures ranging from the freezing point to 110° F. Beyond these extremes their resistance varies with the species. It is well known, moreover, that woody plants and many herbaceous plants freeze and thaw without being visibly injured. Forests of larches, birches, and pines grow in Siberia as high as the seventy-second degree of latitude, where the temperature often falls below —50° F. Several kinds of pines, willows, junipers, and alders grow along the Mackenzie River in latitude 69°. Mr. C. Gibbs, of Abbottsford, found in 1882 that the apple crop of twelve Russian villages, on the western bank of the Volga and south of Kazan, was valued at fifty thousand dollars a year. The fruits are sold in the markets of Nijni-Novgorod and Kazan. The region is subject to temperatures, as was experienced in 1887, of —40°. So apples grow well in the northern United States, where such temperatures are not unusual. The greatest resistance to cold is offered by seeds. Next in power of endurance are the cryptogams—mosses, algæ, and fungi. Except the hardy trees and shrubs of the temperate and frigid zones, and the hardy perennial herbs, most of the phanerogams perish between the freezing point and —20°. The most obvious effects of freezing upon plants are noticed in herbs and bulbs, which are stiffened and assume a shining appearance, often oleaginous and transparent. The effects of frost on trees are not visible unless the temperature descends to near zero, when they are often cracked to the center. Internally the sap is congealed in the tissues. Until recently the death of the plant was attributed to the frosts dilating the cells and distending the tissues. During the winters of 1887–'88 and 1888–'89 Signor Cavallero found, with a microscope magnifying three hundred times, that the tissues of a frozen vine were not torn and that the cells were not frozen. The crystals of ice, on the other hand, were formed only in the intercellular spaces. These facts do not afford indications of the vital condition of the plants, for they are observed in those that resist the cold as well as in those that succumb to it. The chemical modifications are of much greater importance, for they determine or attend the death of the frozen plant. Signor Cavallero's data agree with those of MM. Sachs and Jumelle, and point to the thawing as the principal factor of the death, for frozen plants may be made to live by taking precautions to thaw them slowly. In fact, while the plant is thawing rapidly, the water leaves most of the tissues before it is reabsorbed by them; and the abnormal concentration of the tissues provokes death. But when the thawing process is slow, most of the water returns to the cells and restores the equilibrium which primarily existed in them.

Sounds made by Ants.—That ants are capable of producing sounds intelligible to their fellows and even audible to our ears seems to be proved by the experiments of Sir John Lubbock, Landois, Robert Wroughton of Bombay, C. Janet, Forel, E. Warsmann, and others. It also seems to be determined that the sounds are produced by the rubbing together of superficial portions of the body. A simple yet ingenious contrivance is described for enabling an observer to hear and study these sounds. A glass tunnel is set, small end down, in the middle of a square of window glass of five or six inches side, fitting closely enough to prevent the insects crawling out under it. A bunch of ants about as

large as a chestnut and free from any foreign substance is dropped through the tunnel, and that is lifted up at once. While the ants are still confused, and before any of them can reach the edge of the glass, it is covered with another square like it, which has been surrounded, a short distance from its edge, by a pad of putty. This confines the ants and prevents their being crushed. The two plates of glass are pressed together to within about the thickness of an ant's body, but closer on one side than on the other, so as to hold some tight and leave others free to take such positions as please them. On applying this box of ants to the ear as one would a watch, a regular buzzing may be heard like that of water boiling in an open vessel, and with it some very clear stridulations. The ants may be kept alive several hours and even days in this prison if it is not air-tight; and whenever the ants are excited the stridulations may be heard very numerous and intense. The stridulations are supposed to be produced by rubbing the rough scaly surface of the chitinous covering, which is described as looking, when seen in one direction under the microscope, like the teeth of a saw.

Ancient Use of Copper.—The range of metals and alloys at the disposition of the craftsman is really very wide, but he, nevertheless, Prof. Roberts-Austen says, restricts his efforts within narrow limits, and employs but few materials. The pure metals and fine wrought-iron work are seldom used, and have hardly any applications in art industries except when in union with other metals. The two series of alloys which have prominence in the history of art metal work are those of copper and tin, the bronzes, and the copper-zinc series—the brasses. Next in importance should come the lead-tin alloys—the pewters. Of the alloys of the precious metals, the gold-copper, the gold-silver, and the silver-copper are the most important. Taking the bronzes first, the important question at once suggests itself whether copper was employed before the general adoption of the alloy of copper and tin in industrial art. Berthelot has given us the analysis of a little Chaldean statuette of a god, now in the Louvre, which is considered to date from 4000 B. C., and it proved to be of metallic copper. There is also an analysis by Berthelot of the scepter of King Pepi I of the sixth Egyptian dynasty. This scepter, believed to be thirty-five hundred or four thousand years old, now in the British Museum, is of pure copper. From the anthropological point of view copper plays an essentially different part in prehistoric culture now from what was assigned to it a short time ago. Whereas it had been assumed that copper periods existed in Europe only in a few localities, finds of it have recently increased to such an extent that the assumption of a special copper age, which was prior to the bronze age and contemporary with the later stone age, seems to archæologists now inevitable. Many of the objects found in Schliemann's first prehistoric city, Ilios, were of nearly pure copper. Other articles in the third city were of bronze. Our knowledge as to the first appearance of bronze has recently received new evidence in a rod found by Dr. W. Flinders Petrie at Meydum, of the fourth Egyptian dynasty, about 3700 B. C., which proves to be a bronze having about the ratio of nine parts of copper to one of tin, characteristic of far later and even of modern bronzes. Two works in the South Kensington Museum, one Etruscan and the other Greek, afford clear evidence of the introduction of tin into the art of those nations in the fifth century before Christ. The fact that the presence of lead in bronze enabled it to be more easily fused and also to assume a beautiful velvety-brown patina was, in the opinion of the author, recognized far earlier than has been supposed. Lead occurs in the analysis of a fragment of Greek bronze of a date about 450 B. C. The use of zinc is indicated in the descriptions in detail by Pliny of the various shades of color presented by bronze. The use of brass, which was common enough in Roman times, does not seem to have prevailed in England until William Austen, in 1460, made of it the magnificent monument of Richard Beauchamp, Earl of Warwick.

Preservation of Virginian Antiquities.—An Association for the Preservation of Virginian Antiquities was formed in 1888, at the suggestion of ladies of Williamsburg, and chose the wife of Governor Fitzhugh Lee as its first president. Mrs. Lee was succeeded at the expiration of Governor Lee's term by

Mrs. Joseph Bryan, who is now president. The first work of the society was to secure the "old Powder Horn," or powder magazine, in Williamsburg, which was built in 1714, and was the object of historical disputes between Governor Lord Dunmore and the Commons, among whom Patrick Henry was prominent. This building was in a state of decay. It has been repaired and restored to its old proportions and appearance. Next the society saved the picturesque home of Martha Washington in Fredericksburg from being carried off to the Chicago Exhibition by purchasing it. It has been made to look, within and without, as much as possible as it did when Martha Washington lived in it. The house is to be used as a museum for colonial and Revolutionary relics. The churchyard at Jamestown, with its ruin and twenty acres of land adjoining it, have been presented to the association by the owner, Edward F. Burney, and will be preserved and kept in order. The restoration of the Old Brick Church (St. Luke's) in Smithfield, Va., which was built in 1632, is contemplated as the next work of the association; and it is negotiating for the possession of the old lighthouse at Cape Henry, which was used for about one hundred years, but was abandoned about fourteen years ago for a new and more modern structure.

Discovery of a "Missing Link."—Dr. D. G. Brinton communicates to Science an account of the discovery in the early Pleistocene strata of Java of three fragments of three skeletons, that introduce us to a new species, a new genus, and a new family of the order of Primates, *Pithecanthropus erectus*, standing between the apes and man—in other words, apparently supplying the "missing link" which has been so long and so anxiously waited for. The material, Dr. Brinton says, "is sufficient for a close osteological comparison. The cubical capacity of the skull is about two thirds that of the human average. It is distinctly dolicocephalic, about seventy degrees—and its *norma verticalis* astonishingly like that of the famous Neanderthal skull. The dental apparatus is still of the simian type, but less markedly so than in other apes. The femora are singularly human. They prove beyond doubt that this creature walked constantly on two legs, and when erect was quite equal in height to the average human male. Of the various differences which separate it from the highest apes and the lowest man it may be said that they bring it closer to the latter than to the former. One of the bearings of this discovery is upon the original birthplace of the human race. The author (Eugene Dubois, of the Dutch army) believes that the steps in the immediate genealogy of our species were these: *Prothylobates; Anthropopithecus sivalensis; Pithecanthropus erectus;* and *Homo sapiens*. This series takes us to the Indian faunal province and to the southern aspects of the great Himalayan chain, as the region somewhere in which our specific division of the great organic chain first came into being."

The Work of the Naturalist.—With its second number, January 11th, Science gets into good working order, and gives a budget of excellent scientific papers from first hands. Among them is a clear summary of the proceedings of the Baltimore meeting of the American Society of Naturalists during the last Christmas vacation. At this meeting the influence of environment upon the successive steps of development, and as a cause of variation, was discussed with considerable freedom. Prof. Charles S. Minot, of Harvard, spoke on the work of the naturalist in the world, defining his object to be to discover and publish the truth about Nature. First and foremost of the conditions of success is truth. The naturalist's first business is to get at the truth, in the way of which stand as the most prominent obstacles the limitations of his own abilities and the limitations of accessories for carrying on his work. The naturalist must observe, experiment, and reason, and his training must necessarily be along these lines. The great work of the future is to be done by experimenters. Again, the reasoning faculty is one of our weakest points. The naturalist must learn to distinguish carefully between discussion and controversy, and while being led and taught to indulge freely in the former with all the intelligence at his command, he must also be taught to avoid the latter. The naturalist is exposed to many evils like this matter of controversy, which tend to cause him to depart from his proper mission

of getting at the truth. He is especially liable to be led away by impatience to get results. Preliminary communications are a very great as well as a very prevalent evil. The greed for priority leads many even fine workers far astray. The tendency to speculate is a third evil, and a fourth is the disposition to accept too readily simple and well-finished conceptions. It is the function of original memoirs to assimilate crude facts and render them digestible. Details not bearing directly on the subject should be carefully excluded. Most original papers could be "boiled down" to one half and some even to one tenth of the amount that is really published. The effect of the work of the naturalist upon his own character is best shown by his optimism. One drawback in the naturalist's life is his comparative loneliness and isolation. Seldom has he in his own neighborhood another interested in the same particular line as himself. Reunions of naturalist societies counteract this to a considerable extent, but there is need of even greater affiliation. Naturalists should exercise influence in teaching men competence. The solution of our present political troubles lies not so much in restricting the right to vote as it does in restricting the right to be a candidate. We, as naturalists and as citizens, should uphold competence. The naturalist should see that the schools educate, with science in its proper place.

The Senses of Plants.—The conclusion is reached by J. C. Arthur in a president's address before the Indiana Academy of Science on The Special Senses of Plants, that plants seem to react sensitively to gravity, light, moisture, heat, and contact. Each is a special kind of sensitiveness having its own method of reaction. Two or more kinds of sensitiveness may reside in the same organ, when its position will be a resultant of the several forces. There are consequently no exclusive organs of sense, although there is more or less localization in certain parts, and there are no nerves, although the motor impulse may be transmitted some distance, even so far as twenty inches or more in very vigorous Sensitive Plants—that is, in *Mimosa*. There are also no muscles in plants, although they execute movements of very considerable amplitude. The real mechanism by which the movements are accomplished is not well understood. There is agreement, however, in assuming it to be due to the movement of water. All the senses, except that of contact, have for their end the adjustment of the plant as a whole, and of each of its organs, in a suitable position for heat development. The contact sense has been more variably developed, aiding the plant to climb, to catch insects for food, and, if we are to accept Darwin's suggestion, enabling the Sensitive Plant in particular to escape the injury of hailstones. All the movements are very slow, except a few like insect-catching and hail-avoiding movements, and their wonderful diversity and extent are realized only by instituting carefully devised experiments and the use of delicate instruments. It is to be noted that the same organ always responds to the same stimulus with the same corresponding movement. There is no opportunity for choice, no volition, and consequently no mental activity, no psychic life of even the most humble and rudimentary nature.

Characteristics of Maps.—Maps, said Dr. R. H. Mill, in a lecture on Holiday Geography at the Royal Geographical Society's rooms, may be viewed as a kind of shorthand, and are easier to read than books. Far more information is given in a map than could be written or printed upon a piece of paper of equal size, and a map could point out to several persons coming from different directions the way to a certain place, since it does not introduce the confusing notices of right and left, as verbal instructions do. In Aberdeen the confusion is avoided, because there a man is told to go north or south instead of to the right or left; and it is even said that in some places in Scotland the position of the dishes on the table is regulated by the same principle. The value of maps depends on their purpose and their accuracy. A map that had been taken from a tramp, exhibited to the audience, though worthless for the measurement of distances, was very valuable to the beggar, since all the houses were marked upon it, and the character of their inhabitants, together with the presence of dogs, were indicated by peculiar signs. In a number of old pictorial maps various strange animals were seen disporting them-

selves. Such maps, like a bird's-eye or "balloon" map, give a very good idea of the locality, but in them the scale is continually changing, so that they do not fulfill the true function of a map, to enable measurements to be made. In plans, as distinguished from maps proper, the ground is treated as if level, and no notice is taken of the curvature of the earth. A map proper makes allowance for mountains and hills and the earth's curvature. The speaker referred to the pleasure a traveler might obtain from marking out his journey day by day on a map. Nothing can more convince a man how little he knows of his own country than a map on which are indicated all the railways he has traversed. He would find the places he had seen much less numerous than those he had not.

NOTES.

THE course of eighteen lectures and conferences on social problems of the day, which was begun February 13th under the auspices of Columbian University, Washington, is to be continued, with three lectures a week, till March 28th. The conferences have special reference to the labor question, which will be considered from the points of view of ethics, economics, politics, education, and religion. Each conference is introduced by an address from a chosen speaker.

ATTENTION has been recently directed to the artificial cultivation of India-rubber trees. Those of mature size of one species are found in the Royal Botanic Gardens at Trinidad to produce the gum in paying quantities; and several species of the genus have thriven there. Dr. Ernst urges that every effort be made to extend and preserve the forests, thickets, and groves on the Orinoco, and suggests that collectors be required when they work a grove to plant a certain number of trees. Only by such means, and by adopting a chemical mode of coagulation instead of the present crude way of evaporating the juice in the dense smoke of a wood fire, can the India-rubber production of the Amazon territory be increased in quantity and improved in quality.

THE clock school at Furtwangen, in the Black Forest, Germany, established by the Duke of Baden in 1877, furnishes three years' instruction in preparatory, clockmaking, and supplementary courses. It comprises theory and practice, the higher mechanics, and electricity. The means of instruction include a large collection of all kinds of tools, instruments, drawings, models, etc., and carefully constructed and equipped school premises. Factories, electric plants, etc., are often visited under the direction of the teachers or of the mechanics employed in the places visited. The library contains books relating to clock and watch making, and the technique and mechanics of clock and watch making and electricity. Reading rooms, drawing rooms, laboratories, etc., are open to the pupils daily.

IN the department of reptiles of the Paris Museum is a snake which climbs up the vertical smooth wall of its glass cage. It is about a foot long, and starts on its climb by lifting its head against the glass to a height of about six inches. It then disgorges through its salivary and lachrymal glands an abundant secretion of viscous mucus, which serves as an adhesive liquid and permits it to raise itself still higher till the hinder end of its body is no longer in contact with the floor of the cage. It climbs thus all the way up, very slowly.

ASSUMING that if man was already present in the United States when the Indian tribes first came here, his remains would be most likely to be found in caves near the Appalachian Mountain passes, Mr. H. C. Mercer, of the University of Pennsylvania, examined the caves of the New, Kanawha, and Ohio Rivers along six hundred miles of their course, and failed in all to find any traces of pre-Indian wanderers. He remarks also, in his paper describing his research on the absence from the caves of remains of any of the older animal inhabitants of the region.

THE final report of the committee of the British Association on the Circulation of Underground Water represents that the exceptionally dry season rendered a special inquiry necessary as to the rate of descent of the underground water line and the rate of its subsequent restoration. The drought had made clearly plain the weakness of gravitation water supplies. The quality of the water in the best reservoirs steadily deteriorated as the quantity stored was reduced. The great value of underground water supplies was strongly brought out by the present yield of the Gainsborough Local Board well. Its total depth was thirteen hundred and sixty-one feet, and the yield of twenty thousand gallons an hour, in spite of the drought, did not fall off.

A CURIOUS list of laws is published as having been enacted at a recent grand palaver of the inhabitants of Abbeokuta, West Africa, who call themselves Egbas. They provide that "the practice of striking English silver coins upon the ground or upon stones to test them should cease, and that all English silver coins, whether new or old, should be received as a legal medium"; that the worship of the Shopernee, or smallpox, be discontinued throughout the country; and

that vain boastings against the white men should stop. Other enactments relate to the prohibition of the slave trade and of seizure of strangers for debt.

A PICTURE reproducing two photographs of the little bittern, in the attitudes it assumes to favor concealment, shows, in one of the figures, the bird standing in a reed bed erect, with neck stretched out and beak pointed upward, and looking very much like one of the reeds; the other picture representing the bird crouching against a tree stump at the riverside, in an attitude equally deceptive. W. H. Hudson remarks that the South American little heron, in the reed beds of the pampas, can not, when lost sight of, be found without the aid of dogs, even when the spot where it had lighted is marked.

OBITUARY NOTES.

THE science of astronomy lost three of its most devoted servants during December, 1894. The first was Dr. Carl Friedrich Wilhelm Peters, Director of the Königsberg Observatory, who died December 2d. He was a son of Prof. C. A. Peters, and was born in 1844 at the Pulkowa Observatory. Having studied at Berlin, Kiel, Munich, and Göttingen, he was made a member of the staff of the Hamburg, then of the Altona, and then of the Kiel Observatories, and finally, in 1883, Director of the Königsberg Observatory and Professor of Astronomy in the university. His name is associated with valuable work in pendulum observations; chronometer tests for the determination of the influence of magnetism and atmospheric moisture on the daily rate; and calculations of the orbits of the planet Sylvia, of several comets, and of the double star 61 Cygni. His labors in astronomical literature were considerable, and included the publication of numerous popular papers and the editing of important books.

Father Francesco Denza, who died in Rome, December 14th, was Director of the Vatican Observatory. He was born in 1834, entered the order of Reformed Franciscans and afterward of Barnabites; showed himself very proficient in mathematics at college; and, combining his favorite studies with his theological course at Rome, became a pupil of Father Secchi in astronomy and meteorology. He was active in promoting the study of meteorology in Italy; invented several meteorological instruments; determined the magnetic elements at various places in Italy, Dalmatia, and Africa; observing meteors, he furnished the materials from which Prof. Schiaparelli deduced his theory of those bodies; adapted the Vatican Observatory to the requirements of modern astronomy, and took part there in the international work of charting the heavens; and wrote a volume entitled The Harmony of the Heavens, besides many papers on meteorology and physics.

Arthur Cowper Ranyard, editor of Knowledge, died at his home in Bloomsbury, London, on the same day with Father Denza, December 14th. He was born in 1845, and was a pupil of Prof. De Morgan. He was trained to the law, but his strong attachment to mathematics and astronomy prevailed. He was elected a Fellow of the Royal Astronomical Society when only eighteen years old. He co-operated with George De Morgan in founding the London Mathematical Society, and became one of the honorary secretaries of it. He was a member of the Council of the Royal Astronomical Society and honorary secretary for six years. He was predominantly interested in solar physics and astronomical photography; undertook three different expeditions at his own expense to observe the solar corona during eclipses; was also diligent in the study of the structure of the stellar universe. Results of his devotion to these fields of research are seen in the Old and New Astronomy, which he completed after Mr. Proctor's death, and in the pages of Knowledge, where he struck out a line for himself and which fairly shone with its reproductions of solar photographs.

DR. F. B. HAWKINS, one of the oldest members of the medical profession in England, and a member of the Royal Society of sixty years' standing, died December 7th, at the age of ninety-eight years.

PROF. LEWIS R. GIBBS, of the College of Charleston, S. C., died November 21, 1894, aged eighty-four years, he having been born in August, 1810. He had been a professor in the College of Charleston from 1838 to 1892, or about fifty-four years — first, of mathematics, afterward of astronomy, chemistry, and physics. Previous to 1838 he had been tutor in mathematics in South Carolina College, and had afterward studied in Europe. From 1848 to 1853 he was engaged by the United States Coast Survey to make observations for determining the difference of longitude between Charleston and Washington, D. C., Charleston and Savannah, Ga., and Charleston and Raleigh, N. C. Beginning with 1858, he wrote articles on subjects connected with astronomy, natural history, etc., for various publications, among which were the Charleston Mercury, the Boston Journal of Natural History, the Proceedings of the American Association, the Charleston Courier, the Proceedings of the Elliott Society of Natural History of Charleston, and the Canadian Entomologist. An article on the Occultator, published in the American Journal of Science, March, 1869, was reprinted in journals in England and France. While his favorite study was astronomy, he was at home in almost every branch of modern science.